EFFECTS OF HIGH INTENSITY OCEANIC LIGHTNING DISCHARGES ON THE EARTH'S IONOSPHERE

By

LEVON ALEKSANDROVICH BARSIKYAN

B.S.E.E., University of Colorado Denver, 2011

A thesis submitted to the

Faculty of the Graduate School of the

University of Colorado Denver in partial fulfillment

of the requirements for the degree of

Master of Science

Electrical Engineering

2013

This thesis for the Master of Science degree by

Levon Aleksandrovich Barsikyan

has been approved for the

Electrical Engineering Program

by

Mark Golkowski, Chair

Yiming Deng

Tim Lei

July 15, 2013

Barsikyan, Levon Aleksandrovich (M.S., Electrical Engineering)

Effect of High Intensity Oceanic Lightning Discharges on the Earth's Ionosphere

Master's Thesis directed by Associate Professor Mark Golkowski

ABSTRACT

Very Low Frequency (VLF 3-30 kHz) receivers are used to monitor the amplitude and phase of signals from powerful naval VLF communication transmitters. Since the VLF transmitter signals propagate in the Earth-ionosphere waveguide, they provide a method for remotely sensing ionospheric density changes. The effect of powerful natural oceanic lighting discharges on the ionosphere are investigated using VLF remote sensing and the Global Lighting Detection Network (GLD360). Ionospheric disturbances known as Lighting-induced Electron Precipitation (LEP) events and Early/Fast events are investigated. A comprehensive numerical model of the electron precipitation process is used to compare to observation. Results are compared to previous research on lightning effects on the ionosphere.

The form and content of this abstract are approved. I recommended its publication

Approved: Mark Golkowski

DEDICATION

To my family in Sochi, Russia and most of all to my father Aleksandr Leonovich Barsikyan , my mother Nadezhda Arutovna Barsikyan and my sister Ustina Aleksandrovna Barsikyan.

ACKNOWLEDGEMENTS

I would like to thank and express my deepest gratitude to my adviser Dr. Marek Golkowski for providing me valuable support and having a positive impact on my life. Nick Gross, for helping me with numerical modeling of LEP events in the WIPP simulation. My magnificent parents, for believing and supporting me. My father, Aleksandr Leonovich Barsikyan, for his influence and hard headedness that pushed me to achieve a Master's of Science and teaching me to realize how important education is in life. My mother, Nadezhda Arutovna Barsikyan, for her significant support influence and caring love that guided me through college. My beautiful, smart and little sister, Ustina Aleksandrovna Barsikyan, for being the best sister anyone can ask for and helping me grow up.

TABLE OF CONTENTS

CHAPTER

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

INTRODUCTION

Lightning can be described as a high current electric discharge or a form of plasma that exists within our environment. Although this phenomenon is short lived, about 30 msec, the path length is measured in many kilometers. Lightning transpires when a region of the atmosphere acquires an electric charge large enough that the electric field affiliated with the charge causes electrical breakdown of the air. This natural phenomenon is commonly produced from thunder clouds, although there are cases where lightning has struck in sandstorms, snowstorms and clouds that are formed over spewing volcanoes [Uman, 1969].

The effects of lightning are not generally broad but have major significance on technology, like power lines, electric towers, buildings, and also signal processing and the communication world. The topic of this thesis is the assessment of Narrowband data from Very Low Frequency (VLF) receivers located at three sites, identification and analysis of large over the land and over the ocean lighting-induced electron precipitation events (LEP Events) and its effects on the ionosphere. We will analyze several events found in very low frequency (VLF) recordings. This chapter will provide basic background knowledge for the topic and the contributions of the present work.

Scientific Background

In this section we provide an introduction and basic background knowledge of matter, its four states, and the plasma environment on Earth that is composed of two ionized regions in the upper atmosphere: the ionosphere and magnetosphere.

Matter and the Four States

There are four fundamental states of matter: solid, liquid, gas and plasma. Each state of matter is distinguished by qualitative distinctions and a particular value of binding energy. That can be described as the mechanical energy required to dismantle a whole into parts. Matter in the solid state maintains a permanent volume and shape where the atoms and molecules are tightly bonded together in a crystal type structure. If the average kinetic energy of the molecules in a solid is higher than the binding energy, the crystal will separate directly into gas or a liquid. Unlike solids, properties of matter in the liquid state can take shape when enclosed within a volume or a container where the molecules are not as tightly bonded and exhibit mobility. For a liquid to change into gas the kinetic energy has to exceed the binding energy of the van der Waals forces to break the bonds. In the gaseous state, molecules of matter have very weak bonds and can move around freely and adapt to volume and shape [Uman, 2011]. Similarly, for matter in the gaseous state to change into plasma the kinetic energy of the gaseous atoms and molecules must be higher than the ionization potential of the atoms. In the plasma state, matter has similar properties as gas, there is no definite shape and molecules can move freely and fast. The distinction between plasmas and gases lies within the molecular

composition. Like gases, plasmas are composed of neutral atoms and molecules in addition to a significant number of ionized atoms and unbounded electrons.

Plasma

It wasn't until 1879 when the existence of plasma was discovered by Sir William Crookes using an experimental electrical discharge tube. In 1897, J.J. Thomson discovered the nature of the matter, but it wasn't until 1928 the term "plasma" was introduced by Irving Langmuir. The term was specifically referred to the region of ionized gas where there was no presence of electromagnetic fields. When atoms and molecules of a gas are raised to a high temperature, or exposed to a strong electromagnetic field they become ionized. Ionization of the gaseous state can be achieved by other means such as bombarding the substance with energetic electrons and ions. Other means of ionization include exposure to ultra violet light and X-rays. When ionization takes place the physical behavior of gases is controlled by electromagnetic forces causing the free ions and electrons to conduct electricity.

When referring to plasma, we are talking about the most common visible matter in the universe. Although our planet's atmosphere is made up of non-ionized gas, ionized environment exists in various forms. Sometimes these environments are short lived but examples of their existence include lightning, fire and the aurora borealis.

The Ionosphere

Earth's atmosphere is a layer of gases that acts as a life protecting absorber of solar radiation. The ionosphere is a distinctive region in the upper atmosphere at altitudes of 60 km – 500 km. At about 60 km from the surface of the Earth atmospheric gas

absorbs the constant bombardment of ultraviolet radiation from the sun. During this phenomenon, there is enough energy to ionize the molecules and atoms in this part of the atmosphere making it in the plasma state.

The ionosphere consists of several distinctive ionization peaks, the D, E, and the F regions due to the density and composition of the atmosphere at different altitudes. Altitude plays a significant factor in the composition and density of the ionosphere, because with increasing altitude the gaseous composition of the atmosphere becomes thinner. At these heights free electrons can exist for short amount of time before they are captured by positive ions. This is also called the attachment and recombination process that is produced at different rates for each ionization peaks. These peaks otherwise known as layers are characterized by electron densities that differ in magnitude during the daytime and nighttime. This is due to the contribution of solar radiation during the daytime. Figure 1 displays the electron density of the ionosphere for the daytime and nighttime configuration. There are significant differences in the electron density during the daytime and nighttime particularly in the D and E region due to the effect of solar radiation.

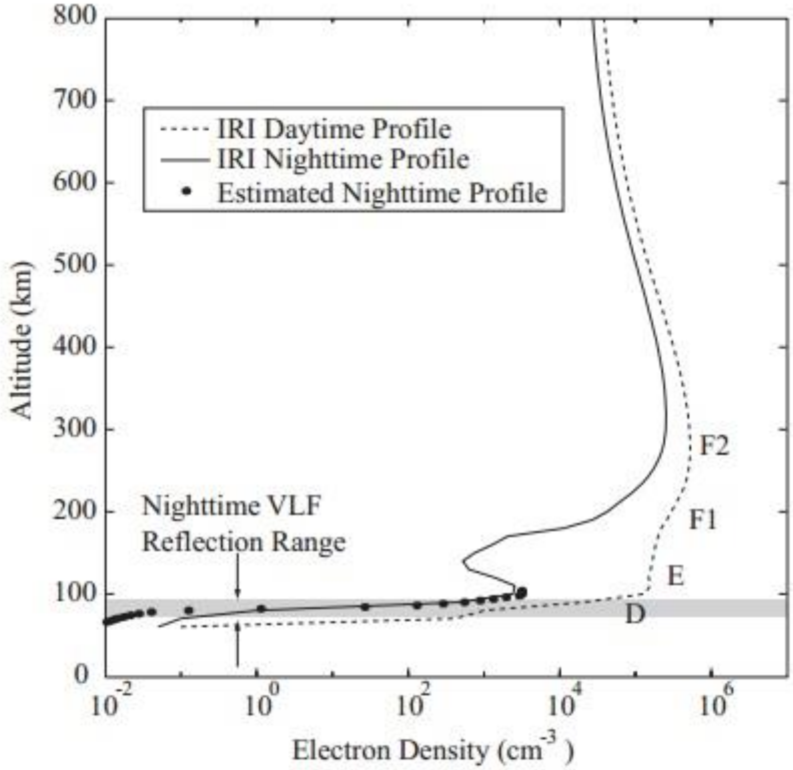

Figure 1.1: Electron density of the ionosphere during the daytime and nighttime.

The D region can be considered as the lowest or the first region of the ionosphere, starting at about 60 km and extending up to ~100 km from the surface of the earth. The recombination phenomenon in this layer is high and the ionization is low. This region of the atmosphere contributes to loss of wave energy due to frequent electron collisions. Overall the ionosphere can be used as a reflecting boundary for the propagation of low frequency waves within the so called Earth-ionosphere waveguide. Propagation in this waveguide can occur only for frequencies where the ionosphere plasma exhibits properties of a good conductor. Plasma acts as a good conductor for frequencies lower than the plasma frequency which is given by $\omega_p = \sqrt{\dfrac{N_e q_e^{\;2}}{\varepsilon_0 m_e}}$. Where N_e is the electron

density, q_e is the electric charge, m_e is the electron mass and ε_0 is the permittivity of free space.

In the ionosphere, plasma densities are such that extremely low frequency (ELF: 300 – 3 kHz) waves or very low frequency (VLF: 3 kHz – 30 kHz) waves have frequencies low enough to be reflected by the medium. A common example of manmade signals in this band is Navy communications with submarines. In this thesis we focus on the direct and indirect effects of lightning discharges in the D region of the ionosphere. Specifically we look at the ionospheric disturbances which occur during the nighttime over the Atlantic Ocean.

The Magnetosphere

The magnetosphere refers to the outermost layer of the Earth's atmosphere, in which the motion of charged particles is dominated by Earth's magnetic field. Overall, the Earth's magnetic field lines resemble a magnetic dipole. At higher altitudes (thousands of kilometers), the field lines get significantly distorted by solar winds. The magnetosphere is composed of several layers, the bow shock, magnetosheath and the magnetopause. The bow shock is outermost layer of the magnetosphere or the boundary between the magnetosphere and stellar medium. This is the boundary where the speed of solar winds drops significantly as it draws near the magnetopause. The magnetosheath, in between the bow shock and magnetopause, is an area contains a small amount of plasma and high particle energy flux varying the direction and magnitude of the magnetic field. The magnetopause is the region where the pressure of the Earth's magnetic field is balanced with the pressure of the solar winds. This is the region of the atmosphere that

changes size and shape with fluctuating pressure from the solar winds. Figure 1.2 displays an illustration of the magnetosphere.

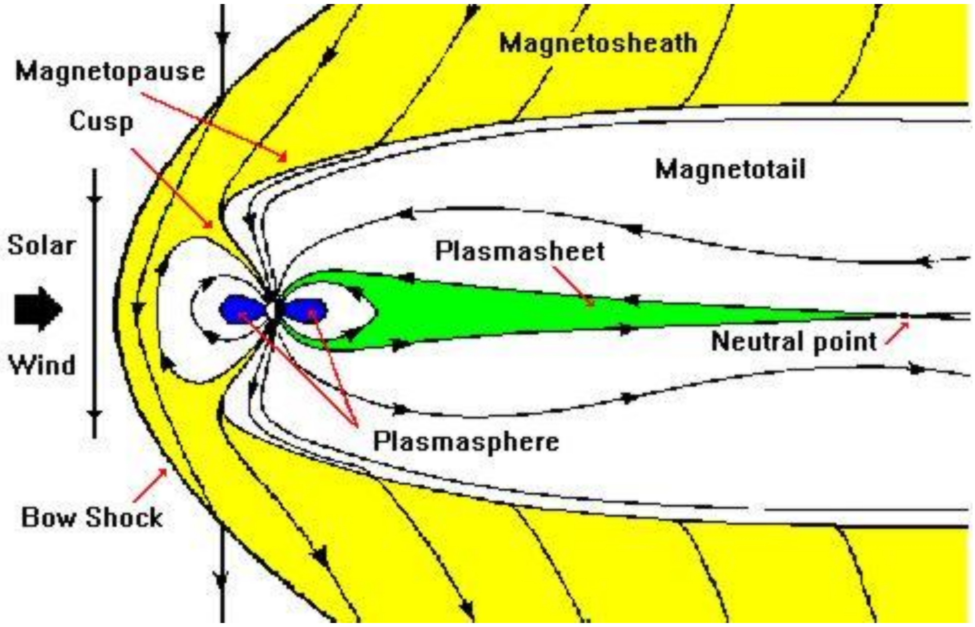

Figure 1.2: Magnetosphere in a nutshell.

The main feature of the magnetosphere relevant to this thesis are the so called radiation belts (or Van Allen Belts) which are highly energetic (keV – MeV) protons and electrons that are trapped in the Earth's magnetic field. If the momentum of these particles is disturbed, they will no longer be trapped in the magnetosphere and will impinge and deposit their energy onto the ionosphere. This deposition of electron energy from the radiation belts is known as energetic electron precipitation. Lighting induced electron precipitation events are a product of very low frequency (VLF) energy radiation from the lighting discharge that escape into the magnetosphere and subsequently produce a precipitation event that leads to an ionospheric disturbance. A fraction of the VLF energy from the lighting discharge gets injected into the magnetosphere and propagates within as a whistler-mode wave. The whistler-mode wave interacts with trapped radiation

belt electrons via cyclotron resonance leading to pitch angle scattering of electrons, causing some of those close to the loss cone to precipitate into the lower ionosphere where they produce secondary ionization [Peter et al, 2007]. Figure 1.3 illustrates the process that results in LEP events.

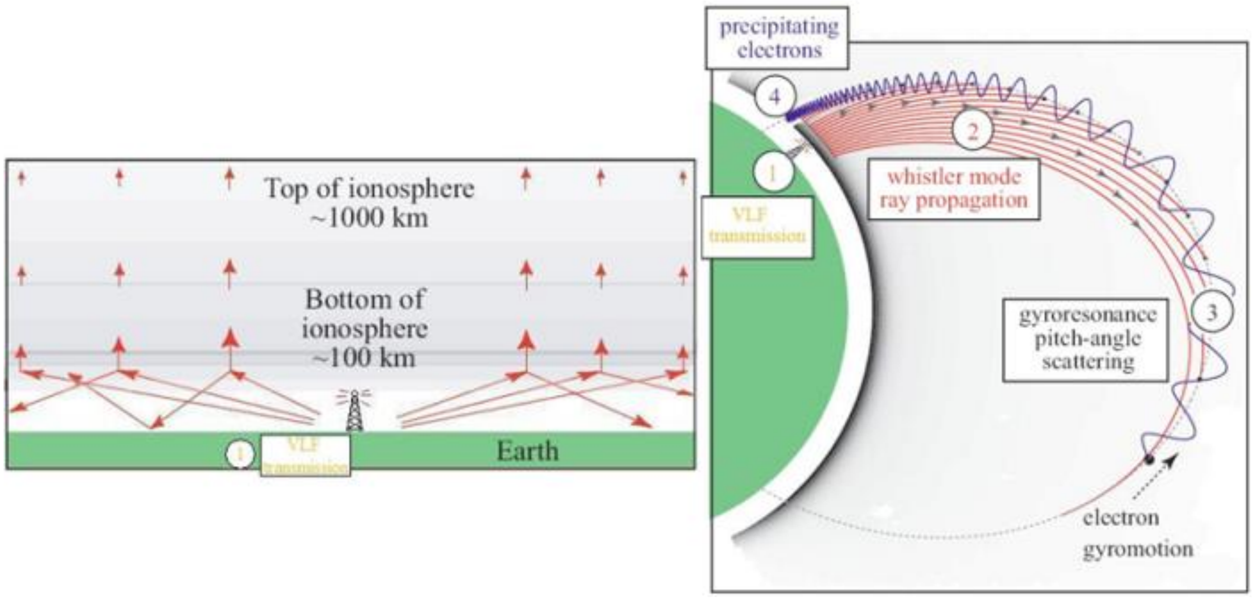

Figure 1.3: Illustration of the left demonstrates the radiating VLF wave energy produced from a lightning discharge. Illustration of the right depicts whistler mode interaction: (1) lighting discharge occurs and a fraction of the VLF signal propagates into the magnetosphere as a whistler mode wave (2) where the injected electrons interact with the trapped energetic radiation belt electrons (3), and (4) the electrons precipitate back down to cause a secondary disturbance in the D region of the ionosphere.

Earth-Ionosphere Waveguide

This section will provide basic knowledge of VLF radio waves and VLF propagation and scattering. For ELF/VLF waves, the Earth-ionosphere waveguide can be modeled as a parallel plate waveguide where the lower plate is the Earth and the upper plate is the D region of the ionosphere. As discussed above, at these frequencies both of these surfaces exhibit behavior of a good conductor.

VLF Radio Waves

Very Low Frequency (VLF) refers to a class of radio waves that range from 3 kHz to 30 kHz in frequency with wavelengths ranging from 10 to 100 kilometers. Applications of VLF include underwater communication, radio navigation services, and secure military communication. At these frequency ranges, radio waves can bounce of the ionosphere and propagate within the Earth-Ionosphere waveguide and penetrate 40 meters into saltwater.

The importance of a large wavelength allows for propagation over large distances. VLF radio waves can be used as a mechanism for sensing disturbances in the lower layer of the ionosphere, the D region. At about 60 km in altitude, VLF radio waves are reflected by the Earth and the ionosphere allowing them to travel around the globe similar to waves in parallel plate waveguide. The propagation solutions are classified into different types of mode: TE modes (Transverse Electric), TM modes (Transverse Magnetic) and the TEM modes (Transverse ElectroMagnetic).

The benefits of VLF radio waves are stability, reliability, and long distance propagation due to very low path attenuation. On the contrary, the frequency band of VLF radio waves has high interferences such as atmospheric noise that are produced by sferics and whistlers. Sferics is an electromagnetic impulse that is produced from lightning discharges and can propagate in the Earth-ionosphere waveguide. Whistlers are a product of sferics, when the electromagnetic energy from a lightning discharge escapes from the Earth-ionosphere waveguide to enter and interact with electrons in the magnetosphere to form a whistler signal.

VLF Propagation and VLF Remote Sensing

When a lightning discharge takes place the D region of the ionosphere is disturbed by direct heating of electrons to change the ionization or by the energetic electron precipitation described above. The disturbance typically happens within a few hundred ms [Johnson, 2000], but the recovery rate of the ionosphere back to its normal state can last from several seconds to several minutes. These disturbances cause changes in the amplitude and phase of a propagated VLF signal. In some cases a disturbance can be very rapid, within a few hundreds of ms, where the recovery rate is very fast and almost non visible in the propagation path of the VLF signal. These sorts of events are classified under “early/fast” events and are caused directly by the electromagnetic wave from the lighting discharge. A different type of ionospheric disturbance is called an LEP (Lightning induced Electron Precipitation) event and involves electromagnetic radiation from the lightning traveling to the magnetosphere, interacting with energetic electrons and causing those electrons to deposit their energy to the ionosphere. The main distinction between early/fast and LEP events is not the recovery time but the cause of the ionospheric disturbance. Only LEP events are caused by electrons “precipitating” or raining from the magnetosphere. In the path of propagation LEP events can have a recovery rate, in the context of amplitude/phase or the ionosphere, in the few seconds to a few minutes range.

VLF remote sensing is the method used for measuring ionospheric disturbances by analyzing measurements of VLF signals. Electromagnetic waves reflect when incident upon conducting boundaries that can be guided inside an enclosed conducting material [Johnson, 2000]. The surface of the Earth and the lowest part of the ionosphere, D-region,

act as a good electrical conductor for VLF signals. This boundary is the so called Earth-ionosphere waveguide that can be classified into two categories; the upper boundary being the D-region and the Earth and Oceans as the lower boundary. The skin depth of saltwater at 10 kHz is ~2.5 m ($\varepsilon_r = 81, \sigma = 4\ S/m$) and ~500 m for the surface of the Earth ($\varepsilon_r = 3, \sigma = 10^{-4}\ S/m$). Below Figure 1.4 illustrates an overview of VLF remote sensing. VLF signals injected into the Earth-ionosphere waveguide by VLF transmitters are picked up by VLF receivers. Data recorded by the VLF receivers map the ionosphere and any disturbances that occurred on any single transmitter to receiver path will be shown on an amplitude and phase plot. Examples can be seen in Section 2.5 of Chapter 2. Section 2.4 of Chapter 2 will cover the overview of VLF transmitters and receivers, the hardware and analysis of the recorded VLF signals.

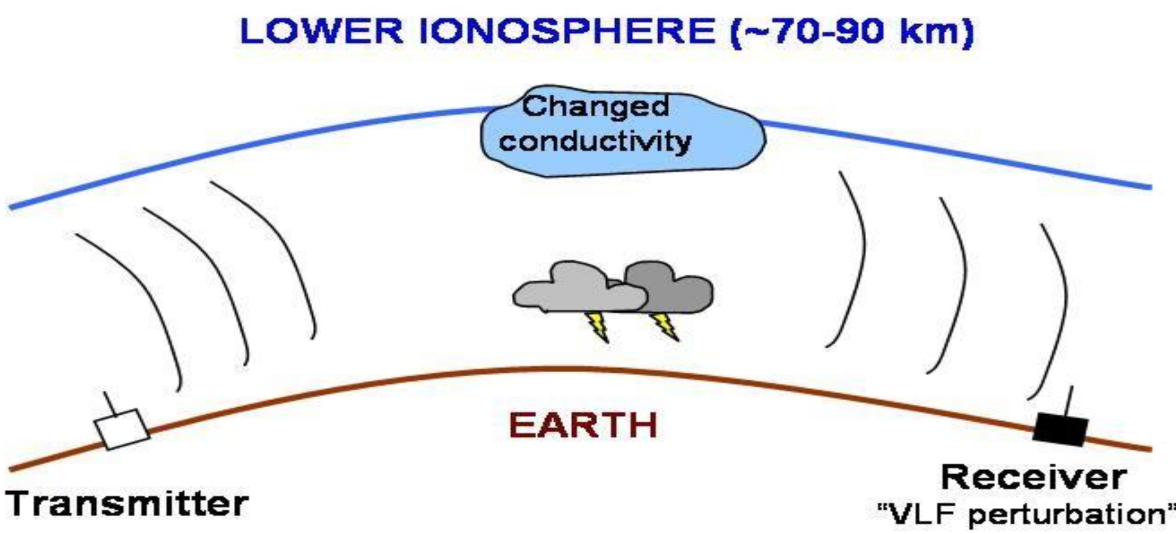

Figure 1.4: System overview of VLF Remote Sensing. VLF signals traveling inside the Earth-ionosphere waveguide sense ionospheric disturbances caused by lighting discharges that are picked up by VLF receivers. Lighting discharges are classified under tow categories, direct or indirect ionospheric disturbances.

Oceanic Lightning

It’s only in the past decade that research in lighting activity has suggested that lightning discharges over the ocean are more intense than over the land flashes. In [Fullekrug et al, 2001] it is noted that lighting activity is higher over the continents, but the majority of the most intense lighting flashes on Earth occur over the ocean in coastal areas. In this published study the occurrence of lightning discharges over the continent and the oceans was estimated and broken into two categories of dusk and dawn. Evidence shows that at dawn approximately 37% of lighting discharges occurred over the ocean and rest of the 63% occurred over continents. At dusk, approximately 85% of lightning discharges occurred over the continent while only ~15% occurred over the ocean. It’s also pointed out that of positive lightning discharges over the continent are more frequent than negative lightning discharges.

Theses Layout

The present work is organized into 4 chapters:

Contents of Chapter 1, the present chapter, include relevant background information for understanding LEP events and the motivation of this work.

Chapter 2 describes the VLF receiver’s hardware, location, data obtained from these receivers and the analysis of this data in discovering VLF signatures of LEP events. The discussion includes a summary of all interesting events found during my research for this work.

Chapter 3 presents in depth analysis of high intensity oceanic lightning-induced precipitation events particularly the events found on the amplitude and phase of the NAU transmitter observed at the Ithaca, NY receiver. Lightning data is analyzed using the GLD360 network to find exact time, date, location and peak current of the causative events. Whistler Induced Particle Precipitation (WIPP) simulation was used to simulate the interactions of unmoded low frequency electromagnetic signals (200 - 60 kHz) within the magnetosphere.

Chapter 4 summarizes the results in Chapter 3and concludes with a discussion of future work and the benefits of our findings on high intensity oceanic events.

Contributions

The contributions of this research can be summarized as follows:

1. Identification of multiple lighting associated VLF events in data from 3 sites over the time span of two years

2. Quantification of effects of unique oceanic lighting events using VLF remote sensing and numerical simulation.

CHAPTER II

INTRODUCTION

In this Chapter we discuss the backbone of our research; data, VLF transmitters and receivers, hardware, location, data processing and analysis and wrap it up with VLF signatures of LEP events.

The effects of lighting on the ionosphere are significant especially in the communication world. Changes in the properties of the ionosphere caused by lighting can cause additional propagation delay and phase distortion in satellite communication. A single lightning strike has 10^{12} Watts's peak power with duration of 50 μsec equivalent to 50 MJ of energy. That amount has peak power equal to the entire grid of the United States which at the time of this writing is approximately 4.2×10^{12} Watts average power. An average of 50-100 lighting flashes occur each second worldwide. Very Low Frequency (VLF) receivers can be used to monitor the effects of lighting activity on the ionosphere. VLF remote sensing is based on high resolution measurements of the amplitude and phase of propagating VLF signals generated by VLF transmitters [Johnson, 2000]. This chapter will provide a description of VLF transmitters and receivers and geographical location used in this research.

Description of VLF Transmitters

The transmission of radio frequencies in the 3-30 kHz range is conducted by the U.S. Navy for military communication with submarines and ships. The large wavelength attributes to long distance propagation in the Earth-ionosphere waveguide by overcoming any geographical obstacles such as mountains. There are dozens of VLF transmitters that

are setup and operated around the world, but in this thesis we will only focus on the transmitters located in North America. Each transmitter has a designated call sign that corresponds to its location and a specific frequency that each one transmits. This thesis focusses on the analysis of VLF signals transmitted from NAU, NLM and NPM transmitters. The location of all VLF transmitters is shown in Figure 2.1.

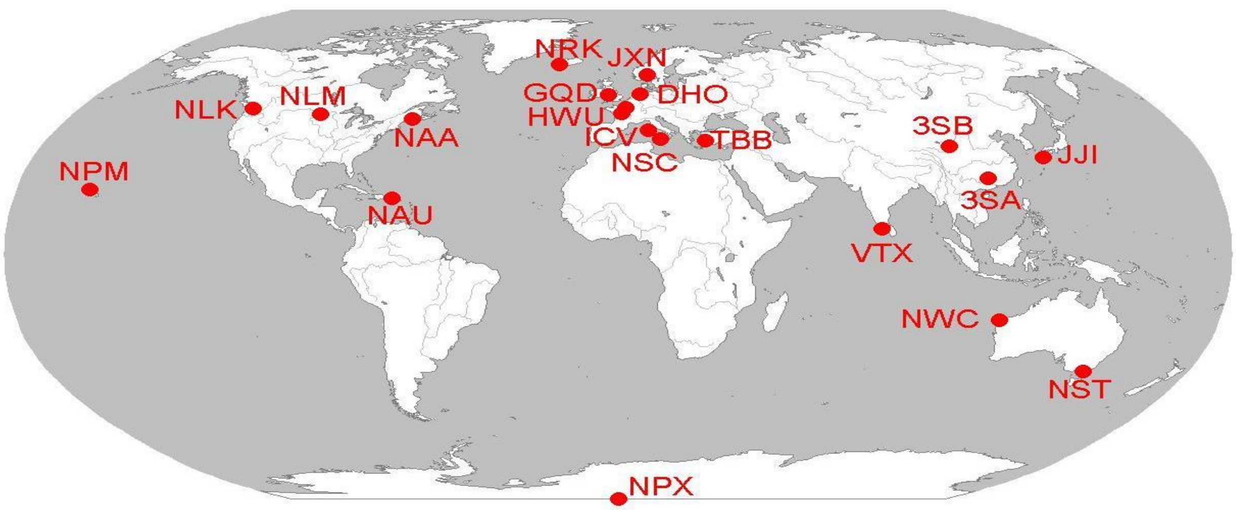

Figure 2.1: World map illustration of the location of VLF transmitters. The relevant transmitters in our study include: NPM (21.4 kHz), NLK (24.8 kHz), NLM (25.2 kHz), NAA (24 kHz), and NAU (40.8 kHz).

We examine LEP events from six different VLF transmitter signals in this research that are listed in Table 2.1. LEP events from each transmitter will be discussed in Chapter 3 of this work, but we focus on two major LEP events that occur on the NAU to Ithaca path.

Table 2.1: List of VLF transmitters used in this work, along with locations, transmitting frequency and power specifications.

Call Sign	Location	Frequency (kHz)	Latitude (N)	Longitude (E)
NPM	Lualuahei, HI	21.4	+21.420166°	-158.151140°
NLM	La Moure, ND	25.2	+46.365990°	-98.335638°
NAU	Aguada, Puerto Rico	40.8	+18.398762°	-67.177599°

Receiver Hardware and Location

The setup of the VLF receivers in this work consisted of two orthogonal air-core, wire loop antennas used to sense the magnetic field of north-south and east-west channels, a preamplifier to match the impedance of the antenna and provide low noise amplification through multiple gain stages, a line receiver that interfaces with the preamplifier, computer and the GPS system. Overview of the system block diagram is shown in Figure 2.2.

Single loop magnetic field antennas are typically used for receiving signals at low frequencies and are typically small in size. For electric field antennas size varies with wavelength, for magnetic loop antennas size is independent of wavelength and they are easy to calibrate. The shape of the antenna is also an independent characteristic as long as it takes a closed formation, in our case the shape is a pyramidal formation. The antennas used in this system is 2.6 m tall, has an area of 1.695 m^2 with .994Ω, 1.005 mH input

impedance. It consists of 12 turns tightly raped around in a triangular formation around PCB pipes and setup upright to form a pyramidal shape.

Once the antenna senses the VLF signal a voltage is induced and fed into a preamplifier that has custom built transformers to match the impedance of the antenna and provides low noise amplification through multiple gain stages. The transformers were set up on the North-South and East-West channels for impedance matching, frequency response and noise performance. Afterwards the signal travels from transmission cable that can range from 100-300 meters to a line receiver located indoors. The line receiver is the “head-end” of the system that is interfaced with the preamplifier, computer and the GPS for timing. System inputs include North-South and East-West and GPS timing. Outputs provide an analog signal, GPS timestamp to computer and power to the preamplifier. Each channel includes a separate anti-aliasing filter card that is output to a 16-bit National Instrument DAQ connected directly via PCI to the computer. Data is sampled at 100 kHz, with 16-bit data resolution, ~32 GB of data in a 24 hour period of continuously sampled on both channels. Once the signal reaches the computer it is converted to digital form through an A/D converter.

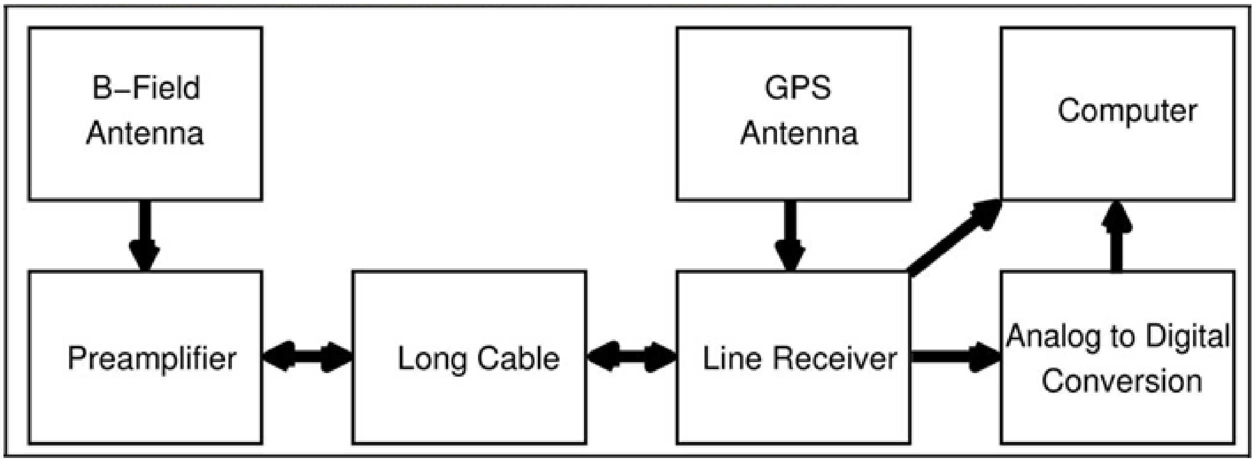

Figure 2.2: Block diagram overview of VLF Receiver system. Two magnetic loop antennas are setup to pick up North-South and East West signal for six different channels.

VLF receivers can be setup and deployed anywhere, but because of noise being high at these frequencies the ideal location would be in a rural area away from the cities. The location of our receivers include: Ithaca NY, Warsaw VA, and Raleigh NC. A geographical representation of these receivers is shown below in Figure 2.3.

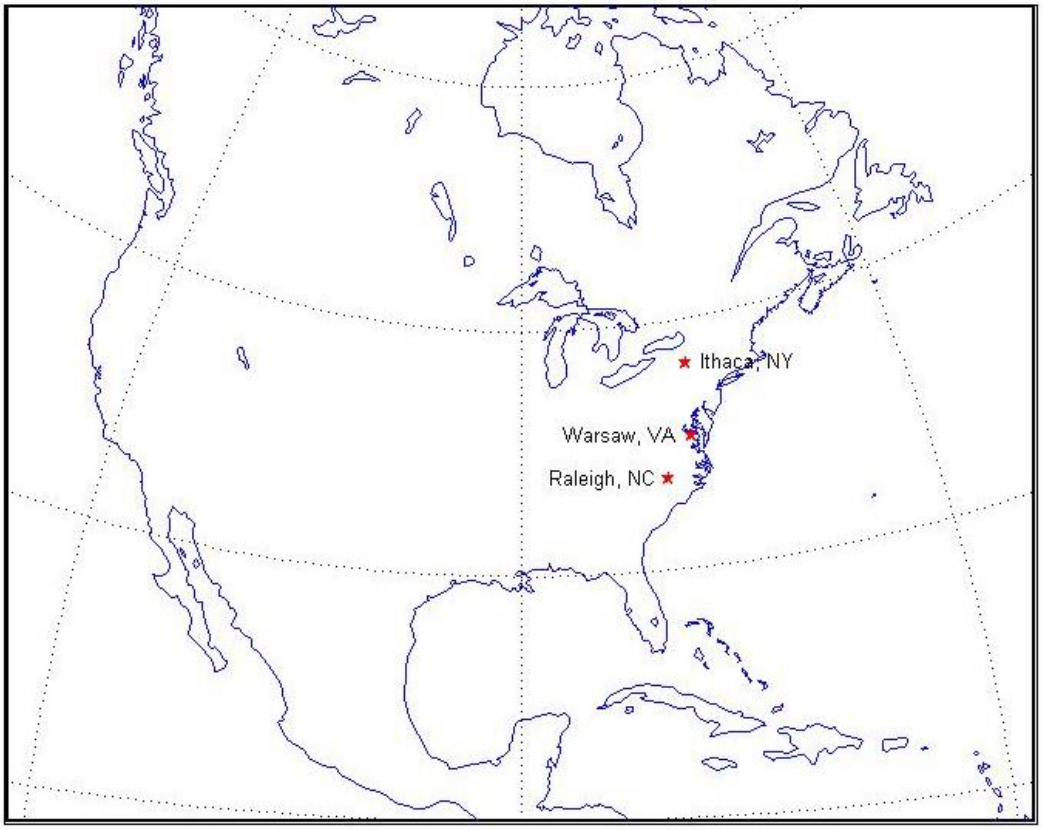

Figure 2.3: Geographic realization of our VLF Receivers.

Data Processing and Analysis

The previous section discussed system overlay of the VLF receivers and the location of VLF transmitters. In this section we will describe how raw data recorded by these receivers is processed and analyzed. As VLF signals are traveling within the Earth-ionosphere waveguide, our VLF receivers are configured to pick up signals within 300 Hz to 47 kHz frequencies. Additionally, the receivers record so called Narrowband files that are mixed down and filtered amplitude and phase of specific frequency transmissions of the VLF transmitters. Each transmitter has a unique frequency that is assigned to it. Given their specific frequencies the transmitters can also be seen on spectrograms. The two magnetic-field antennas are setup to pick up VLF signals from the North-South and

East-West, record and store data on a server with 7 TB of physical storage. Data is sampled on a 24 hour period on both channels at a sampling frequency of 100 kHz. Software has been developed to program sampling schedules, snippets of by obtaining Narrowband signals from the Synoptic broadband signals and send spectrograms via internet. Synoptic (1 minute out of 15 minutes) broadband signals typically range from 3 kHz to 47 kHz in bandwidth that is sampled at 100 kHz. In this work we only utilized Narrowband data to identify and analyze LEP events. All data that is recorded and stored are in .mat format for MATLAB processing. The Narrowband signals are composed of two formats, low resolution and high resolution. The low resolution data is sampled at 1 Hz. High resolution is sampled at 50 Hz for amplitude and phase.

The .mat files are processed in MATLAB. The written code is a function where the inputs are the path name, date, hour and block averaging number. The block averaging number plays a key role in the resolution of the data and filtering of the nose that allows for identification of events. Before the file gets processed it has already been low pass filtered around the frequency of the VLF transmitter in question. To mitigate the effect of impulsive noise in the data, a median filtering technique of variable length is used that is referred to as block averaging. The degree of block averaging is specified by the user before the data is processed. Lower block averaging number outputs a higher resolution amplitude and phase data where noise is much higher, but for high intensity LEP events sferics's can be identified. Chapter 3 will have an example and analysis of high intensity oceanic LEP event with low and high block averaging number. Higher block averaging number yields lower resolution amplitude and phase plots. Examples of higher and lower block averaging effects can be seen in Figure 2.4.

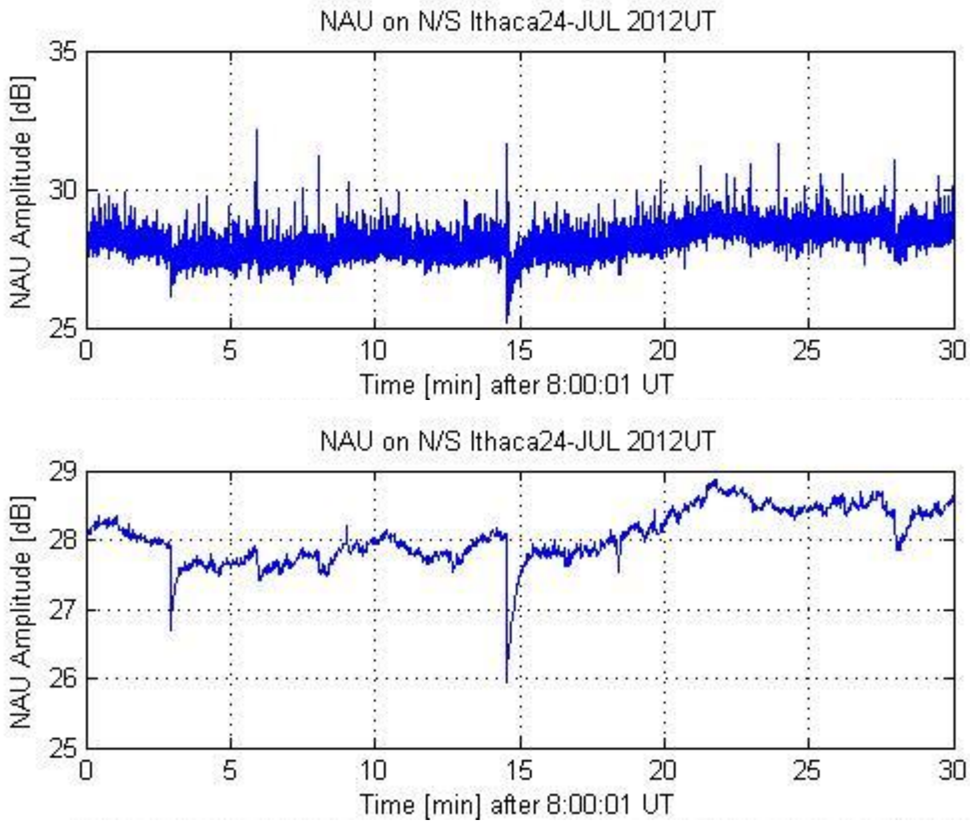

Figure 2.4: Effect of block averaging. The top and bottom panels display the same amplitude signal of the NAU transmitter observed at Ithaca, NY on a 30 minute time axis. The top panel is a snapshot of a VLF signal sampled at a lower block averaging number of 2. The bottom panel is the same VLF signal observed on the top panel but with a higher block averaging number of 50.

A block averaging number above 35 can be very beneficial in identifying visually small LEP events in the presence of significant impulsive noise.

Signatures of LEP Events

Lightning-induced electron precipitation event signatures can have characteristics of positive and negative amplitude drop. Figures 2.5 – 2.8 bellow display a show case of

large/small, continental/oceanic and positive/negative events. Positive amplitude increase events are more rare as they signify a more complex change in the received mode structure of the VLF signal. A negative amplitude drop means that the ionosphere was changed in a way that reduced the amount of VLF signal getting to the receiver. While a positive amplitude change means that the ionosphere was altered to allow more signal to get through.

Lightning polarity is directly related to the direction of current flow between cloud and ground. Negative cloud-to-ground discharges that are the most common occur when negative current flows from cloud to ground. Positive cloud-to-ground discharges occur when positive current flows cloud to ground. Figure 2.5 show a 30 minute time span of VLF signal observed at Warsaw, VA on the North-South amplitude from the NPM transmitter located in La Moure, ND. The top panel of Figure 2.5 displays a VLF signal observed after 4:00 UT for a 30 minute time span showing ~8 event signatures. In those events most signatures are negative discharges, but near 4:17 there is a positive discharge. Two lower panels display the biggest events found within the 30 minute time span near 4:08 and 4:18 UT. The event near 4:08 displays an interesting characteristic with two lightning discharges occurring in succession of each other within a time span of 23 sec apart. Event 1 occurs at approximately at 4:08:35 with a negative drop in amplitude of 3 dB, its initial recovery starts at ~4:08:38 but the ionosphere does not fully recover to its ambient state as another event transpires. The lightning discharge that follows the initial LEP event has larger signal amplitude, above 4 dB, and a slower recovery rate than the initial event. The plot on the bottom right panel displays a ~3 dB amplitude event near 4:18 UT. This LEP signature also displays interesting

characteristics specifically the recovery rate of the ionosphere. In Chapter 3 we will discuss and analyze the recovery rates of LEP events.

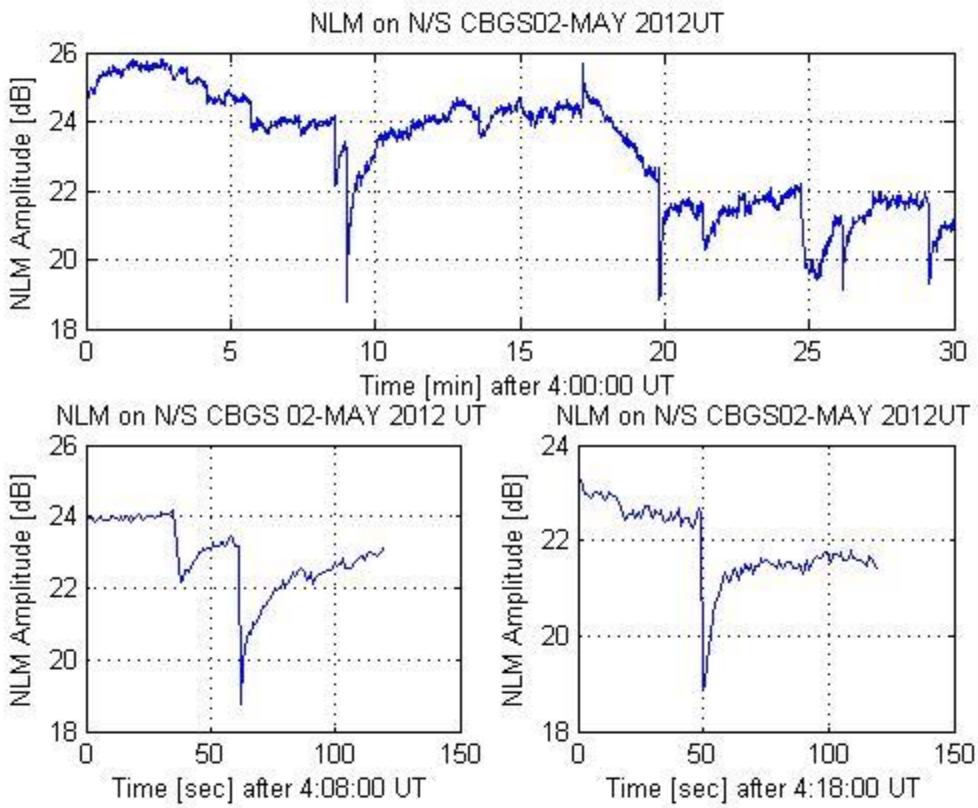

Figure 2.5: Lighting-induced precipitation (LEP) events observed at Warsaw, VA on the North-South amplitude from NLM transmitter in La Moure, North Dakota. The two lower panels show an enlarged time axes of two events near 4:08 and 4:19. LEP event near 4:08 has two consecutive ionospheric disturbances on top of each other.

Figure 2.6 shows an observed LEP event at Warsaw VA on the North-South channel of the NPM transmitter in Lualuahei, Hawaii. The amplitude of the event is in the magnitude of ~6 dB positive drop. Following the initial event is another ionospheric disturbance but hard to examine if it’s a signature of a sfreics or another LEP event. Overall Figure 2.6 is an excellent visual example that displays sferics signatures. The

vertical lines can be considered as the sferics, but the event near 9:16 UT has positive drop in amplitude with a recovery rate of a few tens of seconds.

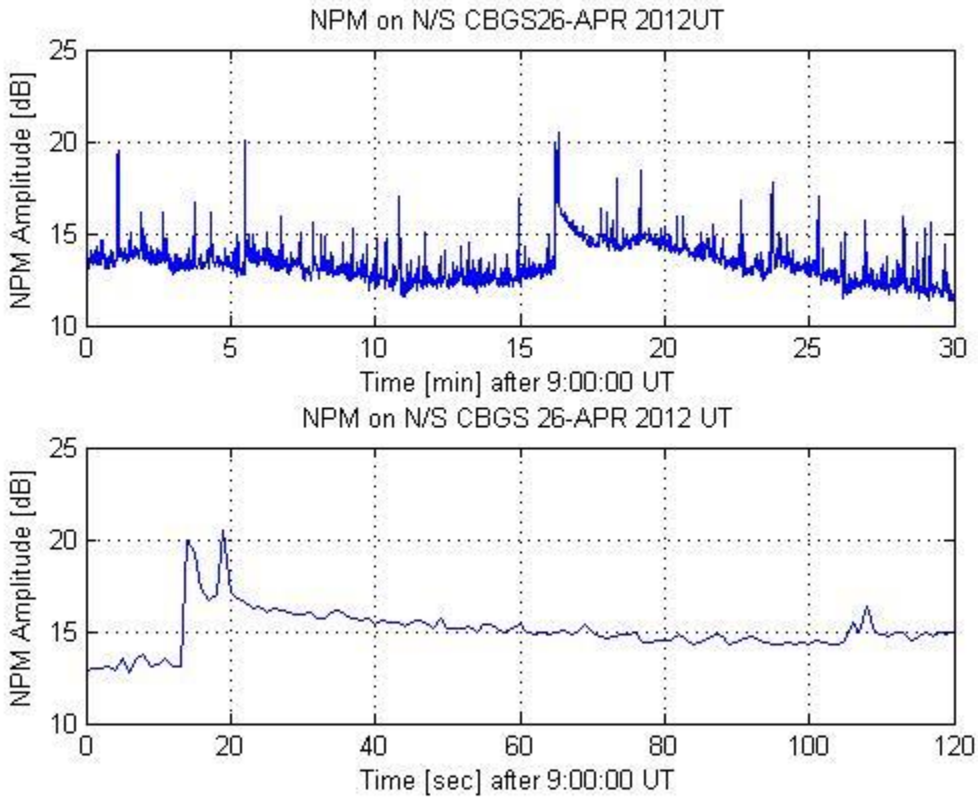

Figure 2.6: LEP event observed at Warsaw, VA on the North-South amplitude from NPM transmitter in Lualuahei, HI. Lower panel shows an enlarged time axes of consecutive events near 9:16.

In Figure 2.7 we observed two LEP events at Warsaw, VA on the North-South channel of the NLM transmitter located in La Moure, North Dakota. Two positive events can be identified near 7:36 UT and 7:38 UT. Both LEP event signatures are ~6 dB in amplitude and exhibit positive amplitude drops. The amplitude of the VLF signal at the beginning of time on the top panel of the figure shows a slow change on the time scale of ~7 minutes. The amplitude change looks like it’s taking the form of a sinusoidal wave, but this non lightning fluctuation of the ionosphere is not addressed in this work.

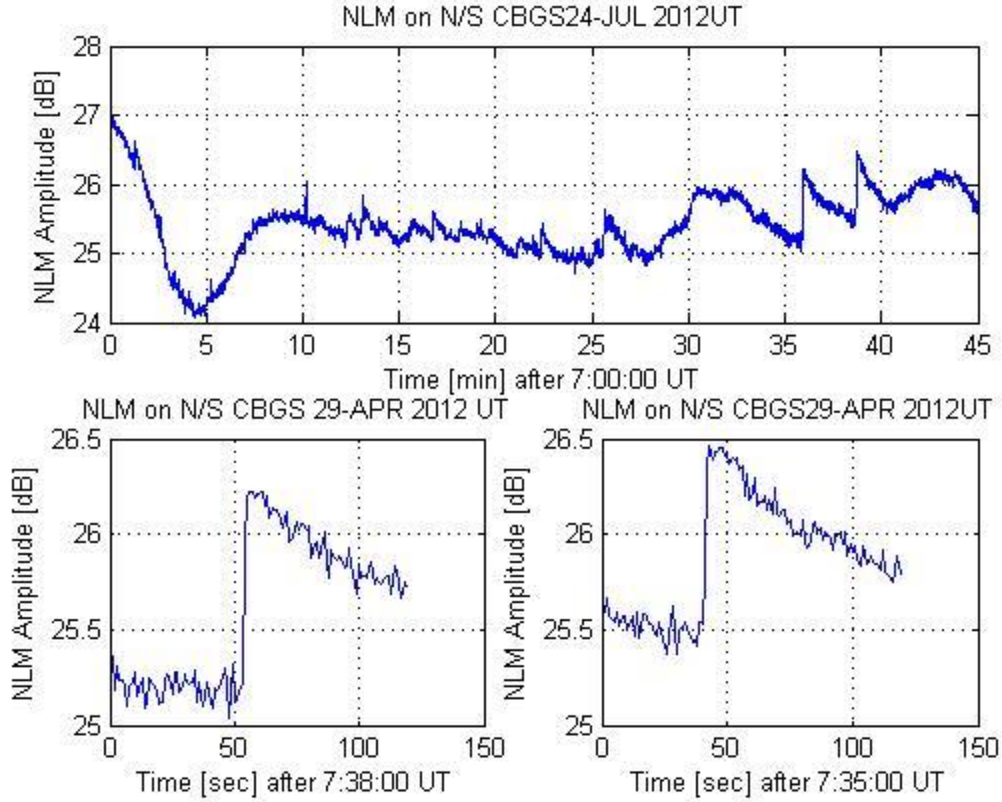

Figure 2.7: LEP signature observed at the Warsaw, VA on the North-South amplitude from NLM transmitter in La Moure, ND. Lower panel shows an amplified time axes of the two events near 7:35 and 7:38.

The LEP event in Figure 2.8 was observed on the Ithaca, New York receiver on the North-South Channel of the NAU transmitter located at Aguada, Puerto Rico. Two large event signatures can be spotted near 8:02 and 8:14 UT on the top panel of Figure 2.8. The two panels on the bottom show both of the events on an enlarged time axes with both exhibiting negative drop in amplitude. The first event near 8:02 UT exhibits approximately1.5 dB drop in amplitude, while the second near 8:14 UT shows a drop of 2 dB in amplitude.

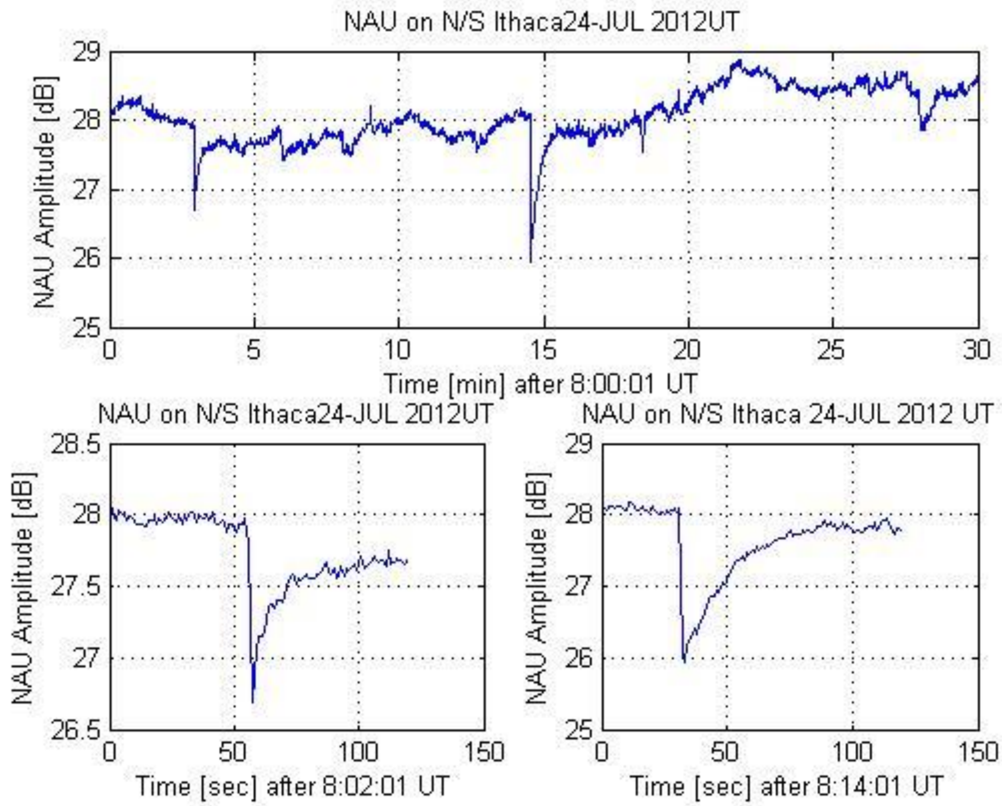

Figure 2.8: High intensity oceanic LEP events observed at the Ithaca, NY receiver on the North-South signal amplitude from NAU transmitter in Aguada, Puerto Rico. The two lower panels show expanded time axes of two large events near 8:02 and 8:14.

Figures 2.5 – 2.8 were generated using MATLAB code with a block averaging number of 50 for each figure. As previously discussed, higher block averaging number yields lower resolution data. Lower resolution data includes less noise thus easing the process of finding LEP event.

During the period of research over 400 ionospheric disturbances were recorded over several months of data. A spreadsheet of all recorded events can be found in Appendix C. All the events found were recorded either on Ithaca, NY receiver or on the Warsaw, VA receiver. The third CU Denver receiver located in Raleigh, NC was not utilized due to hardware issues that are now fixed. Appendix C provides a table of all the

recorded events including receiver location, date, time in UT, transmitter path, negative or positive polarity, amplitude and block averaging number. Ionospheric disturbances from lighting discharges were recorded on all the VLF transmitters in North America even a few events spotted on DHO path from Germany, but most of the events that were seen were on the path of NLK and NAU transmitters. The NLK transmitter is located in Jim Creek Washington, which suggests that any event seen on this transmitter path at one of the three CU Denver receivers located on the East Coast would have to be over the continent lightning discharges. The transmission path of the NAU transmitter, located in Puerto Rico, and our receivers lies over oceanic coastal areas.

CHAPTER III

OCEANIC LEP EVENTS

In this chapter we will expand our discussion of LEP events that were examined in the previous chapter, describe the Vaisala Global Lightning Dataset GLD360 and the role it plays in lightning research, as well as quantitative analysis of LEP Events.

Vaisala Global Lightning Dataset GLD360

The Vaisala Global Lightning Dataset GLD360 is network that provides real-time lightning data [Said et al, 2010]. It's the first global and accurate lightning data system for real-time lightning coverage, early detection and tracking of severe weather. The lighting data includes cloud-to-ground discharges, date and time, latitude and longitude, peak amplitude and polarity of the lightning discharges.

The GLD360 network was used in our works to pin point the location of lightning discharges especially those over coastal areas. The examined LEP events in Figure 2.7 were observed by the GLD360 to provide accurate location, polarity and peak current. Figure 3.1 shows the location of lighting discharges during the time of the two LEP events near 8:02 UT and 8:14 UT.

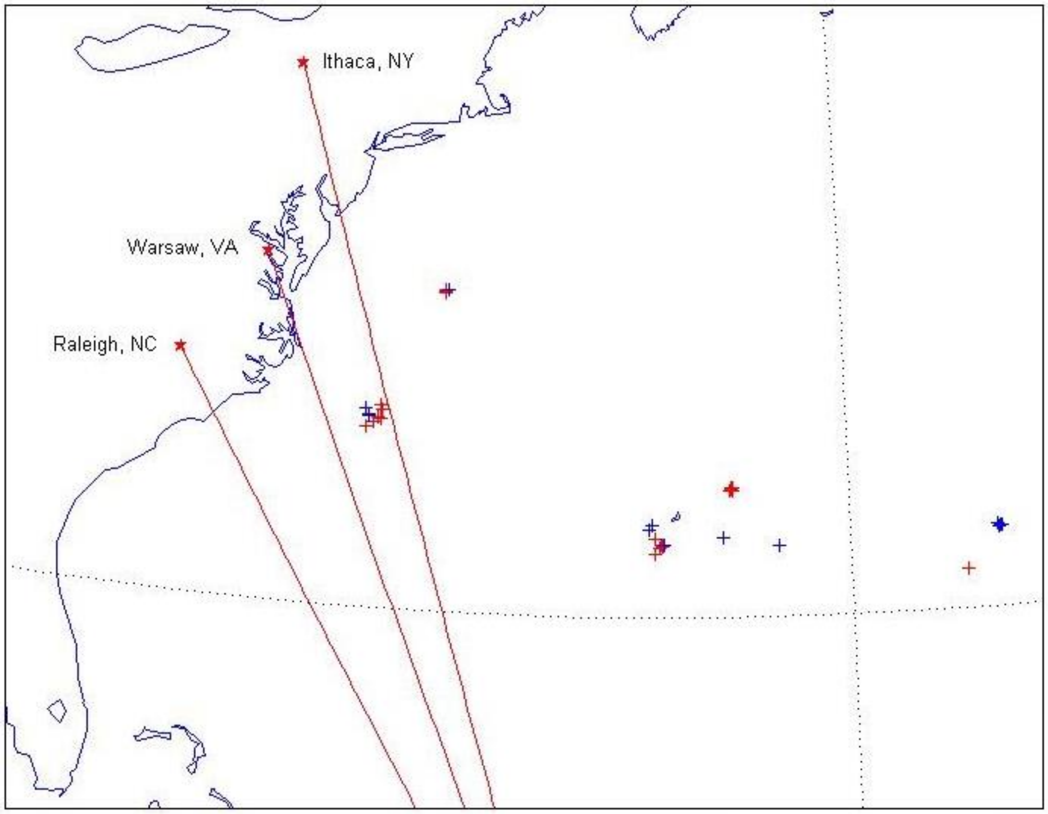

Figure 3.1: Map showing lightning discharges from the GLD360 network associated with LEP signatures shown in Figure 2.7. The events marked in red occurred after 8:02 UT and events marked in blue occurred after 8:14 UT. All three VLF receivers are labeled with the path of propagation shown from the NAU transmitter in Aguada, Puerto Rico.

Oceanic LEP Events on Ithaca to NAU

In Figure 2.7 we show the magnitude of the VLF signal versus time of two large LEP events observed at Ithaca, NY on the North-South amplitude signal from NAU. With confirmation from the GLD360 we are certain that this is an oceanic event that occurred in the coastal area. Figure 3.1 shows a range of events that corresponds to the location of both events. We predicted that the events were located in the cluster near the NAU to Ithaca path. Iterating Figure 2.7 at a lower block averaging (N = 2) we were able to pin point the sferics that caused the VLF signature for both LEP events and there exact

times. With this information we were able find the exact time of the events and correspond them back to the GLD360 data for comparison. Originally it appeared the timing in the VLF data was off by a second, but this was just a software bug where the time stamp on the VLF files jumps to the next second. Our prediction was correct.

Let us classify the VLF signature of the LEP event near 8:02 UT as Event 1 and Event 2 for the signature near 8:14 UT. Below are figures that correspond to each event for reference. Both of the events can be classified as large because the amplitude decrease is on the order of ~1 and ~2 dB.

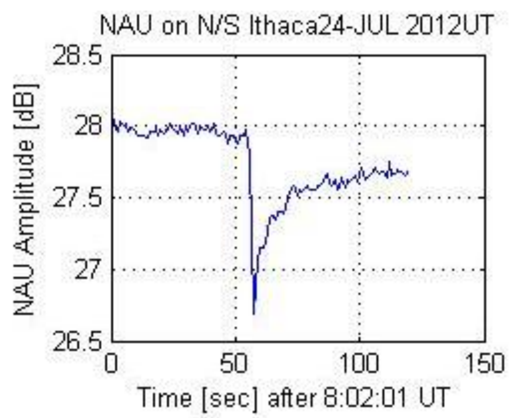

Figure 3.2: Event 1 recorded on Ithaca to NAU path. Amplitude drop seen to be greater than 1 dB.

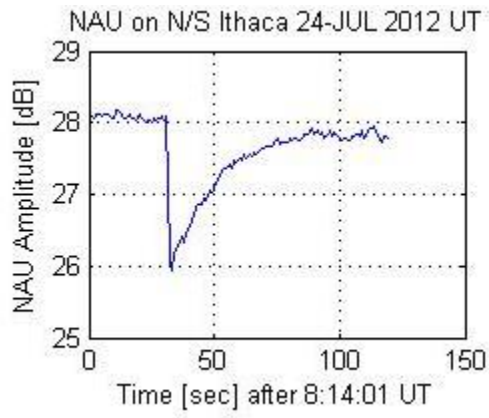

Figure 3.3: Event 2 recorded on Ithaca to NAU path. Amplitude drop seen to be on greater than 2 dB.

Data observed by the GLD360 network associates Event 1 with a negative cloud-to-ground discharge and a peak current of -13 kA. Event 2 was associated with positive cloud-to-ground strike and a peak current of 388 kA. The polarity and peak current values of the cloud-to-ground events associated with the LEP observed in Figure 3.1 are shown in Figure 3.4 and 3.5.

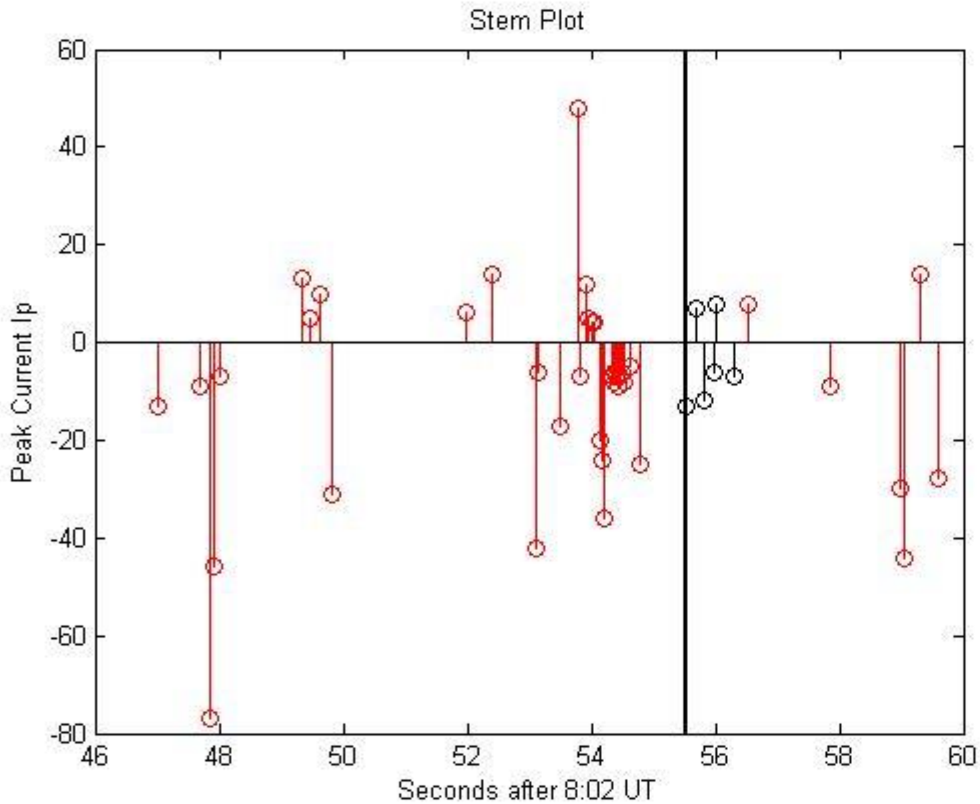

Figure 3.4: Peak Current data from the GLD360 for lightning event associated near 8:02 UT. The back vertical line is the time of the LEP event associated with a negative cloud-to-ground discharge and –13 kA in peak current. Events shown in black (not red) are ones that were located close to the NAU to Ithaca path.

At first we thought that the cause of Event 1 was due to a cluster of negative cloud-to-grounds events that led to a large discharge. Our assumptions were incorrect but evidence points to more interesting fact. After the causative LEP event there were five lightning discharges that with positive and negative polarity that followed that were around the same location.

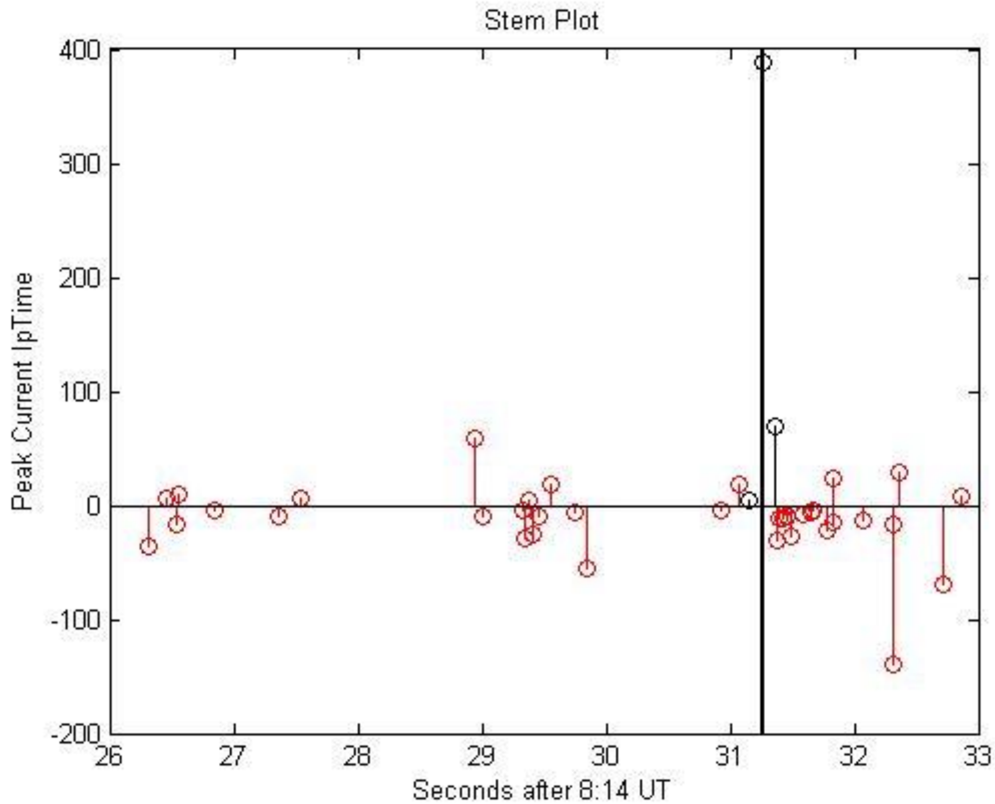

Figure 3.5: Peak Current data from the GLD360 for lightning event associated near 8:14 UT. The back vertical line is the time of the LEP event associated with a positive cloud-to-ground discharge and +388 kA in peak current. Events shown in black (not red) are ones that were located close to the NAU to Ithaca path.

We were hoping to discover a pattern in such large events particularly like Event 2, a 388 kA peak current with a positive cloud-to-ground polarity. Such large events are rarely observed the ocean let alone over continents. Our hopes were to see a cluster of positive events near the location and time growing in peak current value to show that the cause of the event was a built up of other lightning discharges. Unfortunately there was only one positive cloud-to-ground event that followed the 388 kA discharge that was fairly large in peak current value(70 kA) near the same location.

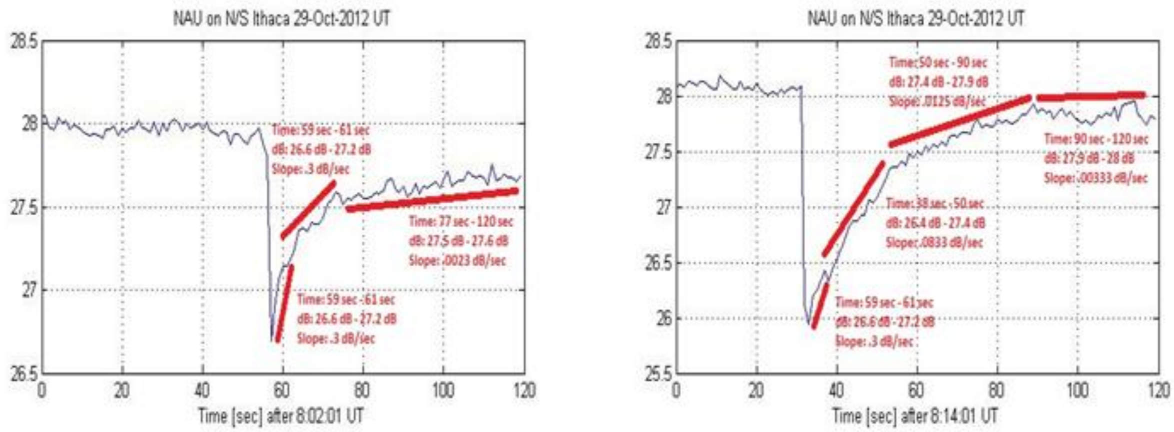

Figure 3.6: Recovery rate analysis of Event 1 and Event 2, over the ocean LEP events.

Part of the analysis we examined the characteristics of recovery rate. In the left panel of Figure 3.6 we can see that the slope of the amplitude recovers to its ambient position at multiple rates with the duration of time. We can observe that the initial recovery is at a much higher magnitude than the rest of slope. In a published study by Inan et al, [1988] similar observations of recovery rates were made and it was concluded that the electron energies involved are in the MeV range. In such cases the high energy portion of the flux penetrates to lower latitudes that the keV flux where the recovery rates are slower.

Perturbations of both events were observed in the NAU phase as well as at the Raleigh, NC receiver on several transmitting paths. The sferics' were identified on the North-South channel of the Ithaca, NY receiver from NLK, NPM, and DHO path as well as on the Raleigh, NC receiver from NPM, NAU, DHO and NLK. The 388 kA event is modeled in the Whistler Induced Particle Precipitation code to simulate the interactions of energetic electrons in the magnetosphere which will be covered in the next section of the chapter.

Whistler Induced Particle Precipitation (WIPP)

The purpose of the Whistler Induced Particle Precipitation (WIPP) simulation code [Bortnik, 2004; Cotts 2011] is to simulate the interactions low frequency electromagnetic signals (200 - 60 kHz) with energetic electrons in the magnetosphere. When used for lightning simulation, the power of the signals are defined by the power spectral density of the lightning strike and injected into the magnetosphere at 1000km.

The simulated magnetosphere is created from satellite data. A ray tracing code is then applied to the magnetosphere with Landau damping [Bortnik, 2004]. The signals are then injected along the rays (along with using interpolation to acquire a higher resolution) and the interaction between the signals and magnetosphere is calculated. The calculation is performed for a set amount of time, typically 5 to 10 seconds, in which the signal will have made multiple hops from one hemisphere to the other along the magnetic fields lines and through multiple L-shells (the plasmapause plays a critical role in how high of an L-shell the signal can travel to).

The most commonly used outputs of the WIPP simulation is the precipitated flux, the electron number flux, and the rms pitch angle change, all of which are a function of L-shell, time, and hemisphere.

There are many different parameters within the WIPP simulation that can be changed. Some inputs are known measured values (e.g. peak current, latitude of the strike). Other inputs are not as straight forward, and require experience and an understanding of the what type of output is intended (e.g. whether the plasmasphere is

smooth or not, what magnetosphere model to use, using a square or sinusoidal loss cone, the shape of the power spectral density from the strike).

Results from the WIPP Simulation

After running WIPP simulation we see that the strength of the precipitating flux of Event 2 was large enough to be seen on all three receivers. For July 24, 2012 nothing was seen on the Warsaw receivers as the transmitters were down that day. Figure 3.7 displays a map of the North and Southern hemisphere of the precipitating flux of energetic electrons caused by the +388 kA event. The lightning impulse of the event caused high power energetic waves to be injected into the magnetosphere, where they obliquely propagate as whistler signals. Interacting with high energy electrons that cause the pitch angle of the electrons to change and deposit some of them in the loss cone to precipitate back down to the ionosphere. Precipitation occurs along the Earth’s magnetic field lines, where high energy electrons can precipitate and cause events in two hemispheres of the Earth.

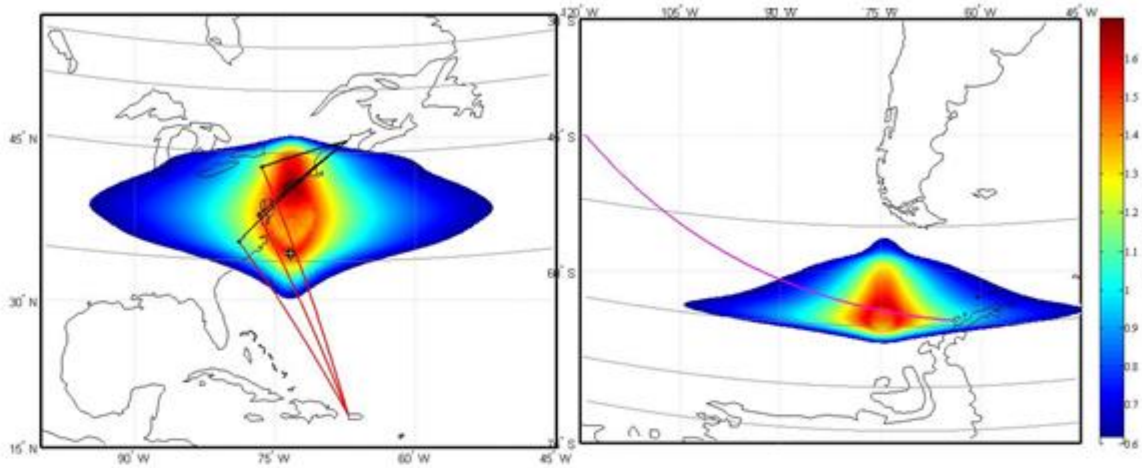

Figure 3.7: Map of the WIPP simulation caused by the 388 kA positive cloud-to-ground lightning discharge. Left panel shows the precipitation flux of the energetic electrons with the black diamond showing the location of the event. Right panel shows the precipitation of energetic electrons in the southern hemisphere.

Figure 3.7 is a simulation of the WIPP code that simulates the precipitation flux caused by the +388 kA event. The less than 20 msec onset delay of the event from the time of the lightning discharge suggest that the observation at Ithaca, NY may be an Early/Fast event not an LEP event. The area of precipitating flux in the southern hemisphere pointed us to further examining this event. We were able to obtain Narrowband data from NPM (Hawaii) to Palmer, Antarctica where the path of propagation goes straight through the densest area of the precipitating flux. The NPM to Palmer path is shown in the right panel of Figure 3.7. The data was analyzed with a block averaging of 1and estimated the time of an LEP event to be at 8:14:31.8. Corresponding to this time we saw the perturbations on our Raleigh receivers to NAA and Palmer to NPM. The key evidence that we are seeing local and conjugate LEP events is that the attenuation of the VLF signal occurs first on the NAU to Raleigh path and slightly later on the NPM to Palmer path. This implies that the lightning discharge

was large enough to cause a significant amount of electrons to enter the loss cone on the first hop and immediately precipitate in the northern hemisphere and then the southern hemisphere few msec later. Figure 3.8 displays the VLF signature of the LEP event seen at NPM to Palmer receiver.

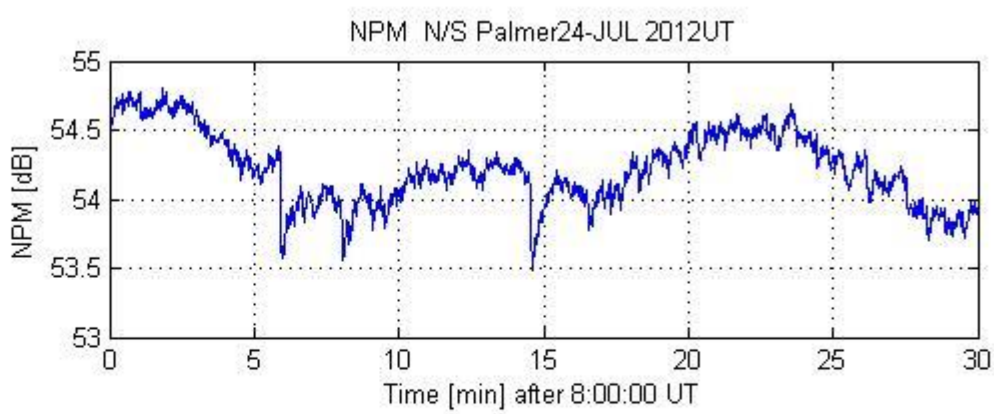

Figure 3.8: VLF signature of the LEP event seen at Palmer on NPM. This is the same event seen at Ithaca on NAU.

Our simulation shows that we should see precipitation of electrons on both hemispheres with registered signatures of LEP events. Analysis of our data proves our hypothesis correct. In fact, our data points to a new discovery in the characteristics of oceanic LEP events in that for the first time effects of a single known lightning event were seen simultaneously in both hemispheres.

CHAPTER IV

Summary and Conclusion

Historically oceanic lightning has received less attention than lightning discharges over the continent. This is particularly due to the lack of accurate lightning detection networks. With the development of the GLD360 the access to accurate data has been more available. Lightning discharges can affect the ionosphere directly or indirectly. Direct effect of the ionosphere alters the conductivity the instant of the discharge and is classified as an Early/Fast event. On a plot of the Narrowband amplitude of a certain VLF transmitter an Early/Fast event will have an onset delay less than 20 msec and onset duration much less than 1 sec. The indirect effect, also called lighting-induced electron precipitation (LEP) events, injects high power energetic waves into the magnetosphere where they are propagated as whistler waves interact with energetic electrons. The interaction of the propagating whistler wave and energetic electrons causes the pitch angle of the electrons to change and deposit some of them in the loss cone to precipitate back down to the ionosphere. Precipitation occurs in the northern and southern hemisphere because the interaction of whistler waves and energetic electrons occurs around the Earth's magnetic field lines. LEP events have a greater onset delay than 20 msecs with a recovery rate of the ionosphere to its ambient level from several seconds to several minutes.

This thesis involved the search for LEP and Early/Fast events in VLF data at three CU Denver receiver locations on the East Coast of the United States. Although over 400 individual events were discovered in several months of data, we focused on a particularly large events observed on the VLF receiver in Ithaca, New York on the path from the

NAU transmitter from Aguada, Puerto Rico. With access to individual lightning strike information from the GLD360 network, specifically date, time, peak current and polarity, we were able to discover high intensity oceanic lightning discharge responsible for the ionospheric perturbation. The initial discovery of the +388 kA event along the coastal area led us to believe that this was an LEP event until further investigation of the timing of the lightning discharge and the VLF perturbation. Simulation with the WIPP code and timing evidence pointed to the +388 kA event causing an Early/Fast event on the NAU to Ithaca path and also precipitation of electrons in both hemispheres. The LEP event in the southern hemisphere was confirmed with data on the NPM to Palmer, Antarctica path. For the first time specific ionospheric perturbation in both hemispheres were identified to be caused by a single large lighting event.

REFERENCES

Bortnik, Jacob. *Precipitation Of Radiation Belt Electrons By Lightning-Generated Magnetospherically Reflecting Whistler Waves*. Thesis. Stanford University, 2005.

Cotts, Benjamin R.T. *Global Quantification Of Lightning-Induced Electron Precipitation Using Very Low Frequency Remote Sensing*. Thesis. Stanford University, 2011.

Cotts, BRT., M. Gołkowski, and R. C. Moore, "Ionospheric effects of whistler waves from rocket-triggered lightning", *Geophysical Research Letters*, vol. 38, no. 24, 2011.

Füllekrug, M., Price, C., Yair, Y., and Williams, E. R.: *Letter to the Editor*
Intense oceanic lightning, Ann. Geophys., 20, 133-137, doi:10.5194/angeo-20-133-2002, 2002.

Golkowski, Marek. *Magnetospheric Wave Injection By Modulated HF Heating Of The Auroral Electrojet*. Thesis. Stanford University, 2009.

Inan, Umran S., and Marek Gołkowski. *Principles of Plasma Physics for Engineers and Scientists*. Cambridge: Cambridge UP, 2011.

Inan, U. S., Burgess, W.C., Wolf, T.G., Shater, D.C., "Lightning-Associated Precipitation of MeV Electrons from the Inner Radiation Belt." *Geophysical Research Letters* 15 (1988): 172-75.

Johnson, Michael Paul. *VLF Imaging of Lightning-Induced Ionospheric Disturbances*. Thesis. Stanford University, 2000.

Johnson, M. *VLF Imaging of Lighting-Induced Ionospheric Disturbances*. Thesis. Stanford University, 2000.

Moore, Michael C. *ELF/VLF Wave Generation By Modulated HF Heating Of The Auroral Electrojet*. Thesis. Stanford University, 2007.

Peter, W. B., and U. S. Inan (2007), A quantitative comparison of lightning-induced electron precipitation and VLF signal perturbations, *J. Geophys. Res*., 112, A12212, doi:10.1029/2006JA012165.

Peter, William Bolton. *Quantitative Measurements Of Lightning-Induced Electron Precipitation Using VLF Remote Sensing*. Thesis. Stanford University, 2007.

Said, R. K., Cohen, M. B., Inan, U. S., Highly intense lightning over the oceans: Estimated peak currents from global GLD360 observations, *Journal of Geophysical Research: Atmospheres,* 2013, **118**, 11

Said, R. K., U. S. Inan, and K. L. Cummins (2010), Long-range lightning geolocation using a VLF radio atmospheric waveform bank, J. Geophys. Res., 115, D23108, doi:10.1029/2010JD013863.

Salut, M. M., M. Abdullah, K. L. Graf, M. B. Cohen, B. R. T. Cotts, and S. Kumar (2012), Long recovery VLF perturbations associated with lightning discharges, J. Geophys. Res., 117, A08311, doi:10.1029/2012JA017567.

Uman, Martin A. *Lighting*. New York: MacGraw-Hill, 1969.

APPENDIX A

Site/Location	Date	Time UT	Transmitter	Positive/Negative	Amplitude of Drop (dB)
Warsaw	4/7/2012	4:30	NPM on E/W	Negative	5 dB
Warsaw	4/7/2012	4:33	NAU on E/W	Negative	.5 dB
Warsaw	4/7/2012	4:30	NAA on N/S | NAA on E/W	Negative	6 dB
Warsaw	4/7/2012	6:42	NAU on E/W	Positive	.7 dB
Warsaw	4/7/2012	8:48	NLM on N/S | NLM on E/W	Negative	1 dB
Warsaw	4/4/2012	2:43	NLM on N/S | NLM on E/W	Positive	1 dB
Ithaca	1/22/2012	12:08	NAA on N/S	Negative	10 dB
Ithaca	1/23/2012	8:36	NPM on N/S | NPM on E/W	Negative	2 dB
Ithaca	1/23/2012	8:57:15	NLK on N/S | NLK on E/W	Positive	.7 dB
Ithaca	1/23/2012	10:49	NLK on N/S | NLK on E/W	Positive	2 dB
Ithaca	1/23/2012	11:03	NLK on N/S | NLK on E/W	Positive	1 dB
Ithaca	1/24/2012	6:58:50	NPM on N/S | NPM on E/W	Negative	1 dB
Ithaca	1/25/2012	2:02	NAA on N/S | NAA on E/W	Negative	N/A
Ithaca	1/25/2012	7:24	NPM on N/S | NPM on E/W	Negative	1 dB
Ithaca	1/25/2012	9:35	DHO on N/S	Negative	8 dB
Ithaca	1/27/2012	9:54	NLK on N/S | NLK on E/W	Positive	.5 dB

Ithaca	1/29/2012	5:31	NLK on N/S | NLK on E/W	Negative	.5 dB
Ithaca	1/29/2012	5:52	NLK on N/S | NLK on E/W	Positive	.5 dB
Ithaca	1/29/2012	5:57	NLK on N/S | NLK on E/W	Positive	.7 dB
Ithaca	1/29/2012	6:08	NAA on N/S	Positive	.1 dB
Ithaca	1/29/2012	7:08	NLK on N/S | NLK on E/W	Negative	.5 dB
Ithaca	1/29/2012	7:51	NLK on N/S | NLK on E/W	Positive	.5 dB
Ithaca	1/29/2012	9:08	NLK on N/S | NLK on E/W	Negative	.6 dB
Ithaca	1/29/2012	9:21	NLK on N/S | NLK on E/W	Positive	1.5 dB
Ithaca	2/3/2012	18:27	DHO on N/S	Negative	1 dB
Ithaca	2/7/2012	20:20	NAA on E/W	Positive	2 dB
Ithaca	2/13/2012	2:23	DHO on N/S	Negative	1 dB
Ithaca	2/15/2012	18:18	NAA on N/S	Negative	.1 dB
Ithaca	2/17/2012	4:53	DHO on N/S	Negative	1 dB
Ithaca	2/17/2012	16:39	NPM on N/S	Negative	1.5 dB
Ithaca	2/17/2012	19:38	NAA on N/S	Negative	.2 dB
Ithaca	2/22/2012	6:20	NAA on E/W	Positive	.2 dB
Ithaca	2/22/2012	6:13	NLK on N/S | NLK on E/W	Negative	.2 dB
Ithaca	2/26/2012	7:45	NPM on N/S | NPM on E/W	Positive	.6 dB
Ithaca	2/26/2012	7:55	NPM on N/S | NPM on E/W	Negative	.2 dB
Ithaca	2/26/2012	8:42	NPM on N/S |	Positive	.3 dB

			NPM on E/W		
Ithaca	2/27/2012	7:44	NPM on N/S | NPM on E/W	Positive	1 dB
Ithaca	2/29/2012	3:43	NLK on N/S | NLK on E/W	Positive	.4 dB
Ithaca	2/29/2012	5:19	NLK on N/S | NLK on E/W	Negative	.2 dB
Ithaca	2/29/2012	5:31	NLK on N/S | NLK on E/W	Negative	.2 dB
Ithaca	2/29/2012	6:39	NLK on N/S | NLK on E/W	Negative	1 dB
Ithaca	2/29/2012	7:14	NLK on N/S | NLK on E/W	Negative	1 dB
Ithaca	2/29/2012	10:25	NLK on N/S | NLK on E/W	Negative	1 dB
Ithaca	2/29/2012	10:16	NAA on N/S | NAA on E/W	Negative	.3 dB
Ithaca	2/29/2012	11:27	NPM on E/W	Negative	.9 dB
Ithaca	3/1/2012	1:47	NLK on N/S | NLK on E/W	Negative	.5 dB
Ithaca	3/1/2012	2:22	NAA on N/S | NAA on E/W	Negative	.4 dB
Ithaca	3/1/2012	2:25:45	NAA on N/S | NAA on E/W	Negative	.2 dB
Ithaca	3/1/2012	2:27	NAA on E/W	Negative	.1 dB
Ithaca	3/1/2012	2:35:50	NAA on E/W	Negative	.5 dB
Ithaca	3/1/2012	4:47	NAA on E/W	Negative	2 dB
Ithaca	3/1/2012	8:19	NPM on E/W	Negative	1 dB
Ithaca	3/1/2012	8:11	NLK on N/S | NLK on E/W	Negative	.5 dB

Ithaca	3/1/2012	8:33	NLK on N/S | NLK on E/W	Negative	.5 dB
Ithaca	3/25/2012	5:32	NPM on E/W	Positive	.5 dB
Ithaca	3/25/2012	9:26	NPM on E/W	Negative	1 dB
Ithaca	3/27/2012	4:18	NLK on N/S | NLK on E/W	Positive	.1 dB
Ithaca	3/27/2012	4:26:50	NLK on N/S | NLK on E/W	Positive	1.5 dB
Ithaca	3/27/2012	5:15	NPM on N/S | NPM on E/W	Positive	2 dB
Ithaca	3/27/2012	5:17	NLK on N/S | NLK on E/W	Positive	.5 dB
Ithaca	3/27/2012	5:23	NLK on N/S | NLK on E/W	Negative	.4 dB
Ithaca	3/27/2012	6:08	NLK on N/S | NLK on E/W	Positive	.2 dB
Ithaca	3/27/2012	6:19	NLK on N/S | NLK on E/W	Positive	1 dB
Ithaca	3/27/2012	6:25	NLK on N/S | NLK on E/W	Negative	1 dB
Ithaca	3/27/2012	6:27	NLK on N/S | NLK on E/W	Negative	.5 dB
Ithaca	3/27/2012	7:41	NLK on N/S | NLK on E/W	Positive	.3 dB
Ithaca	3/27/2012	8:19	NPM on E/W	Negative	.6 dB
Ithaca	3/27/2012	9:54	NPM on E/W	Negative	.3 dB
Ithaca	3/27/2012	9:57	NPM on E/W	Negative	.3 dB
Ithaca	4/1/2012	6:34	NAA on E/W	Negative	.1 dB
Ithaca	4/1/2012	7:44	NAA on E/W	Negative	.1 dB
Ithaca	4/3/2012	6:30	NLK on N/S |	Negative	.2 dB

			NLK on E/W		
Ithaca	4/3/2012	6:52	NLK on N/S | NLK on E/W	Positive	.1 dB
Ithaca	4/3/2012	8:44	NPM on N/S | NPM on E/W	Negative	1.5 dB
Ithaca	4/7/2012	5:39	NPM on E/W	Negative	.2 dB
Ithaca	4/7/2012	5:39	NLK on N/S | NLK on E/W	Negative	.2 dB
Ithaca	4/12/2012	3:13	NPM on N/S | NPM on E/W	Positive	1 dB
Ithaca	4/12/2012	9:48	NPM on N/S | NPM on E/W	Positive	.1 dB
Ithaca	4/12/2012	9:56	NPM on E/W	Positive	.1 dB
Ithaca	4/13/2012	6:22	NPM on N/S | NPM on E/W	Negative	.1 dB
Ithaca	4/13/2012	6:24	NPM on N/S | NPM on E/W	Negative	.1 dB
Ithaca	4/13/2012	6:39	NPM on N/S | NPM on E/W	Negative	1.5 dB
Ithaca	4/13/2012	6:57	NPM on N/S | NPM on E/W	Negative	1 dB
Ithaca	4/13/2012	7:13:30	NPM on N/S | NPM on E/W	Negative	.1 dB
Ithaca	4/13/2012	7:17	NPM on N/S | NPM on E/W	Negative	.5 dB
Ithaca	4/13/2012	7:23	NPM on N/S | NPM on E/W	Negative	1.5 dB
Ithaca	4/13/2012	7:26:50	NPM on N/S | NPM on E/W	Negative	.3 dB
Ithaca	4/13/2012	7:27:30	NPM on N/S |	Negative	.3 dB

			NPM on E/W		
Ithaca	4/13/2012	7:47	NPM on N/S | NPM on E/W	Negative	.2 dB
Ithaca	4/13/2012	7:49:50	NPM on N/S | NPM on E/W	Negative	.4 dB
Ithaca	4/13/2012	8:12	NPM on N/S | NPM on E/W	Negative	.5 dB
Ithaca	4/13/2012	8:47	NPM on N/S | NPM on E/W	Negative	.3 dB
Ithaca	4/13/2012	8:48	NPM on N/S | NPM on E/W	Negative	.2 dB
Ithaca	4/13/2012	9:34	NPM on E/W	Negative	.3 dB
Ithaca	4/13/2012	9:37	NPM on E/W	Negative	.5 dB
Ithaca	4/13/2012	9:45	NPM on E/W	Negative	.5 dB
Ithaca	4/13/2012	10:06	NPM on N/S | NPM on E/W	Negative	.5 dB
Ithaca	4/14/2012	1:38	NAA N/S	Positive	.5 dB
Ithaca	4/14/2012	1:43:50	NAA N/S	Negative	.1 dB
Ithaca	4/14/2012	5:26:30	NLK on N/S | NLK on E/W	Negative	.4 dB
Ithaca	4/14/2012	6:52:45	NLK on N/S | NLK on E/W	Negative	.4 dB
Ithaca	4/14/2012	6:54	NLK on N/S | NLK on E/W	Negative	.3 dB
Ithaca	4/14/2012	6:54:30	NLK on N/S | NLK on E/W	Negative	.1 dB
Ithaca	4/14/2012	6:56	NLK on N/S | NLK on E/W	Negative	.3 dB
Ithaca	4/15/2012	6:19	NPM on N/S	Positive	.5 dB
Ithaca	4/15/2012	6:46	NPM on N/S	Positive	.5 dB

Ithaca	4/15/2012	6:28	NLK on N/S | NLK on E/W	Positive	.2 dB
Ithaca	4/15/2012	6:46	NLK on N/S | NLK on E/W	Positive	.5 dB
Ithaca	4/15/2012	7:50	NPM on N/S | NPM on E/W	Positive	1 dB
Ithaca	4/15/2012	7:56	NPM on N/S | NPM on E/W	Positive	.5 dB
Ithaca	4/15/2012	7:50	NLK on N/S | NLK on E/W	Positive	.5 dB
Ithaca	4/15/2012	8:26	NPM on N/S | NPM on E/W	Negative	1 dB
Ithaca	4/15/2012	8:13	NLK on N/S | NLK on E/W	Positive	.3 dB
Ithaca	4/15/2012	8:26	NLK on N/S | NLK on E/W	Negative	.1 dB
Ithaca	4/16/2012	4:19	NLK on N/S | NLK on E/W	Positive	.3 dB
Ithaca	4/16/2012	4:23	NLK on N/S | NLK on E/W	Positive	.2 dB
Ithaca	4/16/2012	4:27	NLK on N/S | NLK on E/W	Positive	.2 dB
Ithaca	4/16/2012	4:34	NLK on N/S | NLK on E/W	Positive	.1 dB
Ithaca	4/16/2012	4:47	NLK on N/S | NLK on E/W	Positive	.2 dB
Ithaca	4/16/2012	4:54:20	NLK on N/S | NLK on E/W	Positive	.5 dB
Ithaca	4/16/2012	5:21	NPM on E/W	Negative	.2 dB
Ithaca	4/16/2012	5:24:30	NPM on E/W	Negative	.2 dB

Ithaca	4/16/2012	5:03	NLK on N/S | NLK on E/W	Positive	.2 dB
Ithaca	4/16/2012	5:09:30	NLK on N/S | NLK on E/W	Positive	.1 dB
Ithaca	4/16/2012	5:15	NLK on N/S | NLK on E/W	Positive	.2 dB
Ithaca	4/16/2012	5:21	NLK on N/S | NLK on E/W	Positive	.2 dB
Ithaca	4/16/2012	5:33	NLK on N/S | NLK on E/W	Positive	.2 dB
Ithaca	4/16/2012	5:46	NLK on N/S | NLK on E/W	Positive	.3 dB
Ithaca	4/16/2012	6:11	NLK on N/S | NLK on E/W	Positive	1 dB
Ithaca	4/16/2012	9:54	NLK on N/S | NLK on E/W	Positive	.3 dB
Ithaca	4/18/2012	2:42:50	DHO on N/S	Negative	1.5 dB
Ithaca	4/18/2012	6:44	NPM on N/S | NPM on E/W	Negative	.2 dB
Ithaca	4/18/2012	7:47	NPM on N/S | NPM on E/W	Negative	.5 dB
Ithaca NO DATA	4/22/12 - 5/21/12				
Ithaca	5/22/2012	2:26	NAU on N/S	Negative	.2 dB
Ithaca	5/22/2012	2:57	NAU on N/S	Negative	.2 dB
Ithaca	5/22/2012	7:45	NAU on N/S	Negative	.2 dB
Ithaca	5/22/2012	8:27	NAU on N/S	Negative	.2 dB
Warsaw	1/27/2012	8:19	NLK on N/S | NLK on E/W	Negative	1 dB
Warsaw	1/27/2012	8:12	NLK on N/S |	Negative	.4 dB

			NLK on E/W		
Warsaw	1/27/2012	8:19	NLK on N/S | NLK on E/W	Negative	1 dB
Warsaw	1/26/2012	15:56	NAU on N/S | NAU on E/W	Negative	1 dB
Warsaw	1/25/2012	3:07	NAA on E/W	Negative	.1 dB
Warsaw	1/25/2012	3:19	NAA on E/W	Negative	.2 dB
Warsaw	1/25/2012	3:31	NAA on E/W	Negative	.2 dB
Warsaw	1/25/2012	6:35:30	NAA on N/S	Positive	.1 dB
Warsaw NO DATA	1/1/12 - 1/13/12				
Warsaw	2/3/2012	5:18	NLM on E/W	Positive	.2 dB
Warsaw	2/3/2012	5:47	NLM on E/W	Negative	.4 dB
Warsaw	2/3/2012	6:03	NLM on E/W	Negative	.1 dB
Warsaw	2/3/2012	6:08	NLM on E/W	Positive	.1 dB
Warsaw	2/3/2012	6:27	NLM on E/W	Positive	.1 dB
Warsaw	2/3/2012	6:43	NLM on E/W	Negative	.1 dB
Warsaw	2/3/2012	6:48	NLM on E/W	Positive	.1 dB
Warsaw	2/3/2012	6:55:50	NLM on E/W	Positive	.1 dB
Warsaw	2/3/2012	7:38	NLM on E/W	Positive	.2 dB
Warsaw	2/3/2012	8:11:45	NLM on E/W	Positive	.2 dB
Warsaw	2/3/2012	8:19	NLM on E/W	Positive	.4 dB
Warsaw	2/3/2012	9:20:05	NLM on E/W	Positive	.2 dB
Warsaw	2/3/2012	9:44	NLM on E/W	Negative	.6 dB
Warsaw	2/3/2012	10:03	NLM on E/W	Positive	.2 dB
Warsaw	2/3/2012	10:13:45	NLM on E/W	Positive	.3 dB
Warsaw	2/3/2012	10:14:50	NLM on E/W	Positive	.1 dB
Warsaw	2/3/2012	10:19	NLM on E/W	Positive	.1 dB
Warsaw	2/3/2012	10:27	NLM on E/W	Positive	.1 dB
Warsaw	2/3/2012	10:33:45	NLM on E/W	Negative	.1 dB

Warsaw	2/3/2012	10:45:30	NLM on E/W	Negative	.2 dB
Warsaw	2/3/2012	11:03	NLM on E/W	Positive	.1 dB
Warsaw	2/3/2012	11:07	NLM on E/W	Positive	.1 dB
Warsaw	2/3/2012	11:30	NLM on E/W	Negative	.1 dB
Warsaw	2/3/2012	11:44	NLM on E/W	Negative	.1 dB
Warsaw	2/4/2012	1:24	NLK on E/W	Negative	.3 dB
Warsaw	2/4/2012	1:42	NLK on E/W	Negative	.3 dB
Warsaw	2/4/2012	2:19	NLM on E/W	Negative	.2 dB
Warsaw	2/4/2012	4:56	NLM on E/W	Positive	.2 dB
Warsaw	2/4/2012	6:14:30	NLM on E/W	Positive	.2 dB
Warsaw	2/4/2012	10:11	NPM on E/W	Negative	.5 dB
Warsaw	2/4/2012	10:10	NLK on E/W	Negative	.5 dB
Warsaw	2/6/2012	1:46	NAU on N/S | NAU on E/W	Negative	.3 dB
Warsaw	2/7/2012	8:45	NLM on E/W	Positive	.2 dB
Warsaw	2/7/2012	8:53	NLM on E/W	Positive	.4 dB
Warsaw	2/7/2012	9:05	NLM on E/W	Positive	.2 dB
Warsaw	2/8/2012	3:10	NAU on N/S	Positive	.2 dB
Warsaw	2/8/2012	3:30	NAU on N/S	Positive	.2 dB
Warsaw	2/8/2012	5:22	NAU on N/S	Positive	.3 dB
Warsaw	2/10/2012	10:18:30	NAU on E/W	Negative	.5 dB
Warsaw	2/10/2012	11:15:45	NLK on N/S	Positive	.5 dB
Warsaw	2/11/2012	7:40	NAU on N/S | NAU on E/W	Negative	.4 dB
Warsaw	2/11/2012	7:50	NAU on E/W	Positive	.5 dB
Warsaw	2/11/2012	7:54	NAU on N/S | NAU on E/W	Negative	.5 dB
Warsaw	2/11/2012	1:18	NLK on N/S	Negative	.5 dB
Warsaw	2/11/2012	8:13	NAU on N/S | NAU on E/W	Negative	1 dB

Warsaw	2/11/2012	8:23	NAU on N/S | NAU on E/W	Negative	1 dB
Warsaw	2/11/2012	8:25	NAU on N/S | NAU on E/W	Negative	.7 dB
Warsaw	2/11/2012	8:33	NAU on N/S | NAU on E/W	Negative	1 dB
Warsaw	2/11/2012	9:05	NAU on N/S | NAU on E/W	Negative	.5 dB
Warsaw	2/11/2012	9:07	NAU on N/S | NAU on E/W	Negative	.6 dB
Warsaw	2/11/2012	9:12	NAU on N/S | NAU on E/W	Negative	.7 dB
Warsaw	2/11/2012	9:21	NAU on N/S | NAU on E/W	Negative	.7 dB
Warsaw	2/11/2012	9:27	NAU on N/S | NAU on E/W	Negative	.3 dB
Warsaw	2/12/2012	1:43	NAU on N/S | NAU on E/W	Negative	.5 dB
Warsaw	2/12/2012	4:31	NLM on N/S | NLM on E/W	Positive	.3 dB
Warsaw	2/12/2012	10:36	NAA on N/S | NAA on E/W	Negative	.3 dB
Warsaw	2/12/2012	10:38	NAA on N/S | NAA on E/W	Negative	.8 dB
Warsaw	2/13/2012	2:06	NAA on N/S	Negative	.1 dB
Warsaw	2/14/2012	5:16	NAU on E/W	Negative	.4 dB
Warsaw	2/15/2012	2:44:10	NAA on N/S	Negative	.15 dB
Warsaw	2/15/2012	3:56	NLM on N/S	Positive	.5 dB
Warsaw	2/15/2012	8:46	NAA on N/S	Negative	.1 dB
Warsaw	2/16/2012	5:53	NAA on N/S	Positive	.1 dB

Warsaw	2/16/2012	5:44	NLM on E/W	Positive	.1 dB
Warsaw	2/16/2012	5:53	NLK on E/W	Positive	.1 dB
Warsaw	2/16/2012	9:57	NAU on N/S | NAU on E/W	Negative	.5 dB
Warsaw	2/17/2012	5:11	NAU on N/S | NAU on E/W	Positive	.5 dB
Warsaw	2/18/2012	1:22	NAU on N/S	Negative	.3 dB
Warsaw	2/18/2012	2:12	NAA on N/S	Positive	.1 dB
Warsaw	2/18/2012	2:13	NAA on N/S	Negative	.1 dB
Warsaw	2/18/2012	2:17	NAA on N/S	Positive	.1 dB
Warsaw	2/18/2012	2:23	NAA on N/S	Negative	.1 dB
Warsaw	2/18/2012	7:07	NAU on E/W	Positive	.1 dB
Warsaw	2/19/2012	1:18	NAU on N/S | NAU on E/W	Negative	.2 dB
Warsaw	2/19/2012	3:40	NLK on N/S | NLK on E/W	Negative	2 dB
Warsaw	2/19/2012	3:17	NLM on E/W	Positive	.5 dB
Warsaw	2/19/2012	3:40	NAA on N/S	Negative	.2 dB
Warsaw	2/19/2012	3:40	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	2/19/2012	3:47	NAA on N/S | NAA on E/W	Negative	.2 dB
Warsaw	2/19/2012	3:54:50	NAA on N/S | NAA on E/W	Negative	.2 dB
Warsaw	2/19/2012	4:16	NLK on E/W	Negative	2 dB
Warsaw	2/19/2012	5:09	NLK on N/S | NLK on E/W	Negative	1 dB
Warsaw	2/19/2012	5:09	NLM on N/S | NLM on E/W	Negative	.2 dB
Warsaw	2/19/2012	6:23	NAA on N/S	Negative	.2 dB

Warsaw	2/19/2012	6:23	NLM on E/W	Negative	.5 dB
Warsaw	2/19/2012	8:18	NLK on N/S | NLK on E/W	Positive	1 dB
Warsaw	2/19/2012	8:18	NLM on N/S | NLM on E/W	Positive	.5 dB
Warsaw	2/19/2012	9:21	NLM on N/S | NLM on E/W	Positive	.3 dB
Warsaw	2/19/2012	9:24	NLM on N/S | NLM on E/W	Positive	.3 dB
Warsaw	2/19/2012	9:35	NLM on N/S | NLM on E/W	Positive	.3 dB
Warsaw	2/19/2012	10:36	NLK on E/W	Positive	1 dB
Warsaw	2/19/2012	11:03	NLM on N/S | NLM on E/W	Positive	.5 dB
Warsaw	2/19/2012	11:24	NLM on N/S | NLM on E/W	Positive	.5 dB
Warsaw	2/19/2012	11:27	NLM on N/S | NLM on E/W	Positive	.2 dB
Warsaw	2/19/2012	11:32	NLM on N/S | NLM on E/W	Positive	.2 dB
Warsaw	2/19/2012	11:33	NLM on N/S | NLM on E/W	Positive	.2 dB
Warsaw	2/19/2012	10:36	NLM on N/S | NLM on E/W	Positive	1 dB
Warsaw	2/19/2012	11:58	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	2/20/2012	1:18	NAU on N/S | NAU on E/W	Positive	.5 dB
Warsaw	2/20/2012	1:19	NAU on N/S | NAU on E/W	Positive	.7 dB

Warsaw	2/20/2012	1:33	NAU on N/S | NAU on E/W	Positive	.5 dB
Warsaw	2/20/2012	1:21	NAA on N/S | NAA on E/W	Negative	.2 dB
Warsaw	2/20/2012	1:23	NAA on N/S | NAA on E/W	Negative	.2 dB
Warsaw	2/20/2012	2:12	NAU on N/S | NAU on E/W	Positive	.5 dB
Warsaw	2/20/2012	2:19	NAU on N/S | NAU on E/W	Positive	.5 dB
Warsaw	2/20/2012	2:37	NAU on N/S | NAU on E/W	Negative	.6 dB
Warsaw	2/20/2012	2:08	NAU on N/S | NAU on E/W	Positive	.3 dB
Warsaw	2/20/2012	2:08	NLM on N/S | NLM on E/W	Positive	.3 dB
Warsaw	2/20/2012	2:03	NLM on N/S | NLM on E/W	Positive	1 dB
Warsaw	2/20/2012	3:09	NLM on E/W	Positive	.3 dB
Warsaw	2/20/2012	3:34	NAA on N/S	Positive	.1 dB
Warsaw	2/20/2012	3:34	NLM on N/S	Positive	.1 dB
Warsaw	2/20/2012	3:53	NAA on N/S | NAA on E/W	Positive	.3 dB
Warsaw	2/20/2012	3:53	NLM on N/S | NLM on E/W	Positive/Negative	.3 dB
Warsaw	2/20/2012	3:58	NAA on N/S | NAA on E/W	Positive	.1 dB
Warsaw	2/21/2012	6:09	NAU on N/S	Positive	.4 dB
Warsaw	2/22/2012	5:15	NAA on N/S | NAA on E/W	Positive	.2 dB

Warsaw	2/22/2012	5:21	NAA on N/S | NAA on E/W	Negative	.3 dB
Warsaw	2/22/2012	5:33	NAA on N/S | NAA on E/W	Positive	.3 dB
Warsaw	2/22/2012	5:40	NAA on N/S | NAA on E/W	Negative	.4 dB
Warsaw	2/22/2012	5:55	NAA on N/S | NAA on E/W	Positive	.3 dB
Warsaw	2/22/2012	6:13	NAA on N/S | NAA on E/W	Negative	.2 dB
Warsaw	2/22/2012	6:42	NLM on N/S | NLM on E/W	Negative	.2 dB
Warsaw	2/22/2012	8:18	NAA on N/S | NAA on E/W	Negative	.1 dB
Warsaw	2/22/2012	8:42	NAA on N/S | NAA on E/W	Negative	.1 dB
Warsaw	2/22/2012	9:32	NAA on N/S | NAA on E/W	Negative	.2 dB
Warsaw	2/23/2012	1:17	NLM on N/S | NLM on E/W	Negative	.4 dB
Warsaw	2/23/2012	1:19	NLM on N/S | NLM on E/W	Positive	.3 dB
Warsaw	2/23/2012	1:23	NLM on N/S | NLM on E/W	Negative	.3 dB
Warsaw	2/23/2012	1:29	NLM on N/S | NLM on E/W	Positive	.1 dB
Warsaw	2/23/2012	1:37	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	2/23/2012	1:52	NLM on N/S	Positive	.5 dB
Warsaw	2/23/2012	2:11	NLK on E/W	Negative	1 dB

Warsaw	2/23/2012	2:06	NLM on E/W	Negative	.5 dB
Warsaw	2/23/2012	2:11	NAA on N/S | NAA on E/W	Negative	.3 dB
Warsaw	2/23/2012	2:11	NLM on N/S | NLM on E/W	Positive	.3 dB
Warsaw	2/23/2012	2:17	NLM on E/W	Positive	.2 dB
Warsaw	2/23/2012	4:42	NAU on N/S	Positive	.4 dB
Warsaw	2/23/2012	4:40	NLM on N/S	Negative	.5 dB
Warsaw	2/23/2012	5:12	NAU on N/S	Positive	.5 dB
Warsaw	2/23/2012	5:13	NAU on N/S	Positive	.5 dB
Warsaw	2/23/2012	5:14	NAU on N/S	Positive	.5 dB
Warsaw	2/23/2012	5:19	NAU on N/S	Positive	.5 dB
Warsaw	2/23/2012	5:29	NLM on N/S	Negative	.5 dB
Warsaw	2/23/2012	6:43	NAU on N/S	Positive	.5 dB
Warsaw	2/23/2012	6:53	NAU on N/S	Positive	.4 dB
Warsaw	2/23/2012	6:55	NAU on N/S | NAU on E/W	Positive	.6 dB
Warsaw	2/23/2012	5:56	NAU on N/S | NAU on E/W	Positive	.8 dB
Warsaw	2/23/2012	7:03	NAU on N/S	Positive	.5 dB
Warsaw	2/23/2012	7:42	NAU on N/S | NAU on E/W	Positive	2 dB
Warsaw	2/23/2012	8:04	NAU on N/S | NAU on E/W	Negative	1 dB
Warsaw	2/23/2012	8:06	NAU on N/S | NAU on E/W	Positive	.8 dB
Warsaw	2/23/2012	8:15	NAU on N/S | NAU on E/W	Positive	.8 dB
Warsaw	2/23/2012	8:23	NAU on N/S | NAU on E/W	Positive	.7 dB

Warsaw	2/23/2012	8:33	NAU on N/S | NAU on E/W	Positive	1 dB
Warsaw	2/23/2012	8:38	NAU on N/S	Positive	.7 dB
Warsaw	2/23/2012	8:54	NAU on N/S | NAU on E/W	Negative	1 dB
Warsaw	2/23/2012	9:07	NAU on N/S | NAU on E/W	Positive	.6 dB
Warsaw	2/23/2012	9:58	NAU on N/S | NAU on E/W	Positive	.7 dB
Warsaw	2/24/2012	4:49	NLK on N/S | NLK on E/W	Negative	1 dB
Warsaw	2/24/2012	4:45	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	2/24/2012	4:49	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	2/24/2012	6:38	NLM on N/S | NLM on E/W	Positive	.4 dB
Warsaw	2/24/2012	7:29	NPM on E/W	Negative	1 dB
Warsaw	2/24/2012	7:29	NLK on N/S | NLK on E/W	Negative	1 dB
Warsaw	2/24/2012	7:32	NLK on N/S | NLK on E/W	Negative	.8 dB
Warsaw	2/24/2012	7:29	NLM on E/W	Negative	1 dB
Warsaw	2/24/2012	7:57	NLM on E/W	Negative	.2 dB
Warsaw	2/24/2012	8:05	NPM on E/W	Negative	3 dB
Warsaw	2/24/2012	8:04:50	NLM on N/S | NLM on E/W	Negative	1 dB
Warsaw	2/24/2012	8:14	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	2/24/2012	8:14	NAA on N/S |	Negative	.5 dB

			NAA on E/W		
Warsaw	2/25/2012	1:14	NAA on N/S | NAA on E/W	Positive	.3 dB
Warsaw	2/25/2012	1:19	NAA on N/S | NAA on E/W	Positive	.2 dB
Warsaw	2/25/2012	1:23	NAA on N/S | NAA on E/W	Positive	.2 dB
Warsaw	2/25/2012	2:23	NAU on N/S	Positive	.5 dB
Warsaw	2/25/2012	2:36	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	2/25/2012	2:38	NLM on N/S | NLM on E/W	Negative	.7 dB
Warsaw	2/25/2012	3:53	NAU on N/S | NAU on E/W	Positive	1 dB
Warsaw	2/25/2012	3:09	NLM on N/S	Negative	.7 dB
Warsaw	2/25/2012	3:18	NAA on N/S	Negative	.2 dB
Warsaw	2/25/2012	4:08	NAU on N/S	Positive	.8 dB
Warsaw	2/25/2012	4:59	NAU on N/S	Positive	1 dB
Warsaw	2/25/2012	4:32	NAA on N/S | NAA on E/W	Negative	.5 dB
Warsaw	2/25/2012	5:05	NAU on N/S	Positive	.5 dB
Warsaw	2/25/2012	5:06	NAU on N/S	Positive	.2 dB
Warsaw	2/25/2012	5:08	NAU on N/S | NAU on E/W	Positive	.3 dB
Warsaw	2/25/2012	5:28	NAU on N/S | NAU on E/W	Negative	3 dB
Warsaw	2/25/2012	5:31	NAU on N/S | NAU on E/W	Negative	2 dB
Warsaw	2/25/2012	6:07	NAU on N/S | NAU on E/W	Positive	1 dB

Warsaw	2/25/2012	9:11	NAU on N/S | NAU on E/W	Negative	.8 dB
Warsaw	2/28/2012	1:32	NAU on N/S	Negative	.8 dB
Warsaw	2/28/2012	3:32	NAA on N/S	Negative	.1 dB
Warsaw	3/1/2012	1:34	NLK on N/S | NLK on E/W	Positive	1 dB
Warsaw	3/1/2012	1:48	NLK on N/S | NLK on E/W	Positive	2 dB
Warsaw	3/1/2012	1:34	NLM on N/S | NLM on E/W	Positive	1 dB
Warsaw	3/1/2012	1:48	NLM on N/S | NLM on E/W	Positive	2 dB
Warsaw	3/1/2012	2:14	NAA on N/S | NAA on E/W	Negative	.1 dB
Warsaw	3/1/2012	2:14	NLM on N/S | NLM on E/W	Positive	1 dB
Warsaw	3/1/2012	2:27	NAA on E/W	Negative	.2 dB
Warsaw	3/1/2012	2:58	NAA on E/W	Negative	.2 dB
Warsaw	3/1/2012	2:26	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	3/1/2012	3:29	NLM on N/S | NLM on E/W	Positive	.5 dB
Warsaw	3/1/2012	3:44	NLM on N/S | NLM on E/W	Positive	.2 dB
Warsaw	3/1/2012	3:47	NLM on N/S | NLM on E/W	Positive	.5 dB
Warsaw	3/1/2012	4:39	NAA on N/S | NAA on E/W	Positive	.2 dB
Warsaw	3/1/2012	4:59	NAA on N/S | NAA on E/W	Negative	.8 dB

Warsaw	3/1/2012	4:32	NLM on N/S | NLM on E/W	Negative	.3 dB
Warsaw	3/1/2012	4:41	NLM on N/S | NLM on E/W	Negative	.3 dB
Warsaw	3/1/2012	4:49	NLM on N/S | NLM on E/W	Positive	.1 dB
Warsaw	3/1/2012	5:19:50	NAA on N/S | NAA on E/W	Negative	.1 dB
Warsaw	3/1/2012	5:49	NAA on N/S | NAA on E/W	Negative	.4 dB
Warsaw	3/1/2012	5:13:50	NLM on N/S | NLM on E/W	Negative	.2 dB
Warsaw	3/1/2012	5:19	NLM on N/S | NLM on E/W	Positive	.2 dB
Warsaw	3/1/2012	6:43	NAA on N/S | NAA on E/W	Positive	.5 dB
Warsaw	3/1/2012	6:36	NLM on N/S | NLM on E/W	Negative	1 dB
Warsaw	3/1/2012	7:22	NLK on N/S | NLK on E/W	Negative	1 dB
Warsaw	3/1/2012	7:22	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	3/1/2012	7:23	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	3/1/2012	8:58	NAA on N/S	Negative	.1 dB
Warsaw	3/1/2012	8:18	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	3/1/2012	8:56	NLM on N/S | NLM on E/W	Positive	.5 dB
Warsaw	3/3/2012	1:43	NLK on N/S |	Positive	2 dB

			NLK on E/W		
Warsaw	3/3/2012	1:48	NLK on N/S | NLK on E/W	Positive	2 dB
Warsaw	3/3/2012	1:20	NAA on E/W	Negative	.2 dB
Warsaw	3/3/2012	1:37	NAA on E/W	Positive	.2 dB
Warsaw	3/3/2012	1:04	NLM on E/W	Positive	.7 dB
Warsaw	3/3/2012	1:12	NLM on N/S | NLM on E/W	Negative	.7 dB
Warsaw	3/3/2012	1:17	NLM on N/S | NLM on E/W	Positive	.5 dB
Warsaw	3/3/2012	1:33	NLM on E/W	Positive	.4 dB
Warsaw	3/3/2012	1:36	NLM on N/S | NLM on E/W	Negative	1 dB
Warsaw	3/3/2012	1:42	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	3/3/2012	1:48	NLM on N/S | NLM on E/W	Negative	.3 dB
Warsaw	3/3/2012	2:11	NAA on N/S | NAA on E/W	Positive	.1 dB
Warsaw	3/3/2012	2:33	NAA on N/S | NAA on E/W	Positive	.2 dB
Warsaw	3/3/2012	2:57	NAA on N/S | NAA on E/W	Negative	.8 dB
Warsaw	3/3/2012	2:57	NLM on N/S | NLM on E/W	Negative	.8 dB
Warsaw	3/3/2012	3:04	NLK on N/S | NLK on E/W	Positive	1 dB
Warsaw	3/3/2012	3:10	NLK on N/S | NLK on E/W	Positive	1 dB
Warsaw	3/3/2012	3:19:50	NLK on N/S |	Positive	2 dB

			NLK on E/W		
Warsaw	3/3/2012	3:01	NLM on N/S | NLM on E/W	Negative	1.5 dB
Warsaw	3/3/2012	3:04	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	3/3/2012	3:10	NLM on N/S | NLM on E/W	Negative	1.5 dB
Warsaw	3/3/2012	3:19	NLM on N/S | NLM on E/W	Negative	1.5 dB
Warsaw	3/3/2012	5:14	NAA on N/S | NAA on E/W	Negative	.5 dB
Warsaw	3/3/2012	5:19	NAA on N/S | NAA on E/W	Negative	.5 dB
Warsaw	3/3/2012	5:23	NAA on N/S | NAA on E/W	Negative	.3 dB
Warsaw	3/3/2012	5:49:50	NAA on N/S | NAA on E/W	Negative	.6 dB
Warsaw	3/3/2012	5:53	NAA on N/S | NAA on E/W	Negative	.2 dB
Warsaw	3/3/2012	5:50	NAA on N/S | NAA on E/W	Negative	1.5 dB
Warsaw	3/3/2012	5:12	NLM on N/S | NLM on E/W	Negative	1.5 dB
Warsaw	3/3/2012	6:49	NAA on N/S | NAA on E/W	Negative	.5 dB
Warsaw	3/3/2012	6:51	NAA on N/S | NAA on E/W	Negative	.2 dB
Warsaw	3/3/2012	7:04	NLM on N/S | NLM on E/W	Negative	1 dB
Warsaw	3/3/2012	7:20	NLM on N/S |	Positive	.5 dB

			NLM on E/W		
Warsaw	3/3/2012	7:54	NLM on N/S | NLM on E/W	Positive	1 dB
Warsaw	3/3/2012	8:14	NLM on N/S | NLM on E/W	Positive	1 dB
Warsaw	3/3/2012	9:09	NAA on N/S	Negative	.2 dB
Warsaw	3/3/2012	9:17	NAA on N/S | NAA on E/W	Negative	.2 dB
Warsaw	3/3/2012	2:23	NAA on N/S	Positive	.5 dB
Warsaw	3/3/2012	9:32	NAA on N/S	Negative	.2 dB
Warsaw	3/3/2012	9:37	NAA on N/S | NAA on E/W	Positive	.5 dB
Warsaw	3/3/2012	9:06	NLM on E/W	Negative	.5 dB
Warsaw	3/3/2012	9:07	NLM on E/W	Negative	.5 dB
Warsaw	3/3/2012	9:25	NLM on E/W	Negative	.5 dB
Warsaw	3/3/2012	9:39	NLM on E/W	Negative	.5 dB
Warsaw	3/3/2012	9:49	NLM on E/W	Negative	.3 dB
Warsaw	3/3/2012	10:44	NLK on N/S | NLK on E/W	Negative	1.5 dB
Warsaw	3/3/2012	10:44	NLM on N/S | NLM on E/W	Negative	1 dB
Warsaw	3/4/2012	7:29	NAA on N/S | NAA on E/W	Positive	.5 dB
Warsaw	3/4/2012	7:26	NAA on N/S | NAA on E/W	Positive	.5 dB
Warsaw	3/4/2012	7:26	NLM on N/S | NLM on E/W	Positive	.4 dB
Warsaw	3/4/2012	7:49	NAA on N/S | NAA on E/W	Positive	.8 dB
Warsaw	3/4/2012	7:49	NLM on N/S |	Positive	.5 dB

			NLM on E/W		
Warsaw	3/4/2012	8:05	NLM on N/S | NLM on E/W	Positive	1 dB
Warsaw	3/4/2012	8:06	NLM on N/S | NLM on E/W	Positive	.5 dB
Warsaw	3/4/2012	8:09	NLM on N/S | NLM on E/W	Positive	.5 dB
Warsaw	3/4/2012	8:23	NLM on N/S | NLM on E/W	Positive	1.5 dB
Warsaw	3/4/2012	8:38	NLM on N/S | NLM on E/W	Positive	1.7 dB
Warsaw	3/4/2012	9:15	NLK on N/S | NLK on E/W	Negative	.8 dB
Warsaw	3/4/2012	4:42	NAA on N/S | NAA on E/W	Positive	.5 dB
Warsaw	3/6/2012	3:42	NAA on N/S | NAA on E/W	Positive	.2 dB
Warsaw	3/6/2012	6:15:45	NAA on N/S | NAA on E/W	Negative	.3 dB
Warsaw	3/8/2012	4:12:30	NAA on N/S | NAA on E/W	Positive	.1 dB
Warsaw	3/9/2012	9:01:45	NLM on N/S | NLM on E/W	Negative	1.5 dB
Warsaw	3/9/2012	9:02:50	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	3/9/2012	10:27	NLM on N/S | NLM on E/W	Negative	.6 dB
Warsaw	3/10/2012	3:19	NLM on N/S | NLM on E/W	Negative	.2 dB
Warsaw	3/10/2012	5:51	NLM on N/S |	Negative	1 dB

			NLM on E/W		
Warsaw	3/10/2012	6:42	NLK on N/S | NLK on E/W	Negative	1 dB
Warsaw	3/10/2012	6:44	NLK on N/S | NLK on E/W	Negative	1 dB
Warsaw	3/10/2012	6:50:10	NLK on N/S | NLK on E/W	Negative	1 dB
Warsaw	3/10/2012	6:58	NLK on N/S | NLK on E/W	Negative	.5 dB
Warsaw	3/10/2012	6:42	NLM on N/S | NLM on E/W	Negative	1 dB
Warsaw	3/10/2012	6:44	NLM on N/S | NLM on E/W	Negative	1 dB
Warsaw	3/10/2012	6:50:10	NLM on N/S | NLM on E/W	Negative	1 dB
Warsaw	3/10/2012	6:58	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	3/10/2012	6:07	NLM on N/S | NLM on E/W	Negative	.8 dB
Warsaw	3/10/2012	6:37	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	3/10/2012	6:38	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	3/10/2012	6:07	NAA on N/S | NAA on E/W	Negative	1 dB
Warsaw	3/10/2012	6:20	NAA on N/S | NAA on E/W	Negative	1 dB
Warsaw	3/10/2012	6:42	NAA on N/S | NAA on E/W	Negative	.5 dB
Warsaw	3/10/2012	6:44	NAA on N/S |	Negative	.5 dB

			NAA on E/W		
Warsaw	3/10/2012	6:50:10	NAA on N/S | NAA on E/W	Negative	1 dB
Warsaw	3/10/2012	6:58	NAA on N/S | NAA on E/W	Negative	1 dB
Warsaw	3/10/2012	7:01:30	NLM on N/S | NLM on E/W	Negative	.2 dB
Warsaw	3/10/2012	7:01:45	NLM on N/S | NLM on E/W	Negative	2 dB
Warsaw	3/10/2012	7:01:30	NAA on N/S | NAA on E/W	Negative	.2 dB
Warsaw	3/10/2012	7:01:45	NAA on N/S | NAA on E/W	Negative	1 dB
Warsaw	3/10/2012	8:07	NAA on N/S | NAA on E/W	Negative	1 dB
Warsaw	3/10/2012	8:13	NAA on N/S | NAA on E/W	Negative	1 dB
Warsaw	3/10/2012	8:14	NAA on N/S | NAA on E/W	Negative	1.2 dB
Warsaw	3/10/2012	8:13	NLM on N/S | NLM on E/W	Negative	.4 dB
Warsaw	3/10/2012	8:14	NLM on N/S | NLM on E/W	Negative	1 dB
Warsaw	3/10/2012	9:25	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	3/10/2012	9:33	NLM on N/S | NLM on E/W	Negative	.3 dB
Warsaw	3/10/2012	9:37	NLM on N/S | NLM on E/W	Negative	.3 dB
Ithaca	7/17/2012	1:41	NAA on N/S |	Negative	.2 dB

			NAA on E/W		
Ithaca	7/17/2012	1:44	NAA on N/S | NAA on E/W	Negative	.2 dB
Ithaca	7/17/2012	1:54	NAA on N/S | NAA on E/W	Negative	.2 dB
Ithaca	7/17/2012	1:54:30	NAA on N/S | NAA on E/W	Negative	.2 dB
Ithaca	7/17/2012	2:01	NAA on N/S | NAA on E/W	Negative	.8 dB
Ithaca	7/17/2012	2:04	NAA on N/S | NAA on E/W	Negative	1 dB
Ithaca	7/17/2012	2:04:50	NAA on N/S | NAA on E/W	Negative	1 dB
Ithaca	7/17/2012	2:14	NAA on N/S | NAA on E/W	Negative	2 dB
Ithaca	7/17/2012	2:19	NAA on N/S | NAA on E/W	Negative	.3 dB
Ithaca	7/17/2012	3:17	NAA on N/S	Negative	.3 dB
Ithaca	7/18/2012	4:27	NAA on E/W	Positive	.5 dB
Ithaca	7/18/2012	4:34	NAA on E/W	Positive	.5 dB
Ithaca	7/18/2012	4:38	NAA on N/S | NAA on E/W	Positive	.5 dB
Ithaca	7/18/2012	4:54	NAA on N/S | NAA on E/W	Positive	1 dB
Ithaca	7/18/2012	4:59	NAA on N/S | NAA on E/W	Positive	1 dB
Ithaca	7/18/2012	5:03	NAA on N/S | NAA on E/W	Positive	.5 dB
Ithaca	7/18/2012	5:05:30	NAA on N/S | NAA on E/W	Positive	.3 dB

Ithaca	7/18/2012	5:15:30	NAA on N/S | NAA on E/W	Negative	.5 dB
Ithaca	7/18/2012	6:24:50	NAA on N/S | NAA on E/W	Positive	.3 dB
Ithaca	7/18/2012	9:22	NPM on E/W	Negative	.5 dB
Ithaca	7/19/2012	6:24	NAA on N/S | NAA on E/W	Negative	.5 dB
Ithaca	7/19/2012	7:34	NAA on E/W	Negative	.3 dB
Ithaca	7/20/2012	14:06	NAU on N/S	Negative	.3 dB
Ithaca	7/20/2012	14:18	NAU on N/S	Positive	.2 dB
Ithaca	7/21/2012	6:17	NPM on E/W	Negative	.4 dB
Ithaca	7/21/2012	6:34	NPM on E/W	Negative	.5 dB
Ithaca	7/21/2012	6:44:45	NPM on E/W	Negative	.3 dB
Ithaca	7/21/2012	7:26	NPM on E/W	Negative	1 dB
Ithaca	7/22/2012	3:58	NAU on N/S	Positive	1 dB
Ithaca	7/22/2012	5:23	NAU on N/S	Negative	.2 dB
Ithaca	7/22/2012	5:53	NAU on N/S	Negative	.2 dB
Ithaca	7/22/2012	8:23	NPM on E/W	Negative	1.8 dB
Ithaca	7/22/2012	8:28	NPM on E/W	Negative	.8 dB
Ithaca	7/22/2012	8:38	NPM on E/W	Negative	.5 dB
Ithaca	7/22/2012	8:46	NPM on E/W	Negative	1 dB
Ithaca	7/22/2012	8:47	NPM on E/W	Negative	.8 dB
Ithaca	7/22/2012	8:55:10	NLM on N/S | NLM on E/W	Negative	.1 dB
Ithaca	7/23/2012	6:59	NPM on E/W	Negative	1.2 dB
Ithaca	7/24/2012	2:51:50	NAA on N/S | NAA on E/W	Positive	.5 dB
Ithaca	7/24/2012	5:41	NAA on N/S | NAA on E/W	Positive	.8 dB
Ithaca	7/24/2012	6:17	NAU on N/S	Negative	.4 dB

Ithaca	7/24/2012	6:21	NAA on N/S | NAA on E/W	Positive	.7 dB
Ithaca	7/24/2012	6:41	NAA on N/S | NAA on E/W	Positive	1 dB
Ithaca	7/24/2012	6:44	NAA on N/S | NAA on E/W	Positive	1 dB
Ithaca	7/24/2012	6:53	NAA on N/S | NAA on E/W	Positive	1.5 dB
Ithaca	7/24/2012	7:24	NAU on N/S	Positive	.5 dB
Ithaca	7/24/2012	7:24:50	NAU on N/S	Positive	.3 dB
Ithaca	7/24/2012	7:26	NAU on N/S	Positive	.4 dB
Ithaca	7/24/2012	7:32	NAU on N/S	Positive	.3 dB
Ithaca	7/24/2012	7:33	NAU on N/S	Positive	.2 dB
Ithaca	7/24/2012	7:43	NAA on E/W	Negative	.5 dB
Ithaca	7/24/2012	8:03	NAU on N/S	Negative	1.5 dB
Ithaca	7/24/2012	8:14	NAU on N/S | NAU on E/W	Negative	2 dB
Ithaca	7/25/2012	1:39	NAU on N/S	Positive	.5 dB
Ithaca	7/25/2012	1:48	NAU on N/S	Positive	.7 dB
Ithaca	7/25/2012	8:11	NLM on N/S | NLM on E/W	Negative	3 dB
Ithaca	7/26/2012	3:49	NLM on N/S | NLM on E/W	Positive	2 dB
Ithaca	7/26/2012	4:06	NLM on N/S | NLM on E/W	Negative	.5 dB
Ithaca	7/26/2012	4:46	NLM on N/S | NLM on E/W	Negative	.5 dB
Ithaca	7/26/2012	5:43	NLM on N/S | NLM on E/W	Positive	.5 dB
Ithaca	7/26/2012	5:58	NLM on N/S |	Positive	1 dB

			NLM on E/W		
Ithaca	7/26/2012	6:09	NLM on N/S | NLM on E/W	Positive	1 dB
Ithaca	7/26/2012	6:48	NLM on N/S | NLM on E/W	Negative	1 dB
Ithaca	7/26/2012	7:02	NLM on N/S | NLM on E/W	Negative	3 dB
Ithaca	7/26/2012	7:10	NLM on N/S | NLM on E/W	Negative	3 dB
Ithaca	7/26/2012	7:15	NLM on N/S | NLM on E/W	Negative	5 dB
Ithaca	7/26/2012	7:47	NLM on N/S | NLM on E/W	Negative	1 dB
Ithaca	7/26/2012	7:44	NLM on N/S | NLM on E/W	Positive	1 dB
Ithaca	7/26/2012	7:59	NLM on N/S | NLM on E/W	Positive	1 dB
Ithaca	7/26/2012	8:07	NLM on N/S | NLM on E/W	Positive	3 dB
Ithaca	7/26/2012	8:11	NLM on N/S | NLM on E/W	Positive	2 dB
Ithaca	7/26/2012	8:18	NLM on N/S | NLM on E/W	Positive	3 dB
Ithaca	7/26/2012	8:25	NLM on N/S | NLM on E/W	Negative	2 dB
Ithaca	7/26/2012	8:27	NLM on N/S | NLM on E/W	Positive	4 dB
Ithaca	7/26/2012	8:36	NLM on N/S | NLM on E/W	Positive	2.5 dB
Ithaca	7/26/2012	8:43	NLM on N/S |	Positive	3 dB

			NLM on E/W		
Ithaca	7/26/2012	8:59	NLM on N/S | NLM on E/W	Negative	2 dB
Ithaca	7/27/2012	1:17	NAA on N/S	Negative	1 dB
Ithaca	7/27/2012	5:27	NLM on N/S | NLM on E/W	Positive	.5 dB
Ithaca	7/27/2012	5:37	NLM on N/S | NLM on E/W	Positive	1 dB
Ithaca	7/27/2012	5:46	NLM on N/S | NLM on E/W	Positive	.8 dB
Ithaca	7/27/2012	7:00:30	NLM on N/S | NLM on E/W	Positive	.5 dB
Ithaca	7/27/2012	7:09	NLM on N/S | NLM on E/W	Positive	.1 dB
Ithaca	7/27/2012	7:12	NLM on N/S | NLM on E/W	Positive	.3 dB
Ithaca	7/27/2012	9:34:30	NLM on N/S | NLM on E/W	Positive	.3 dB
Ithaca	7/27/2012	9:36	NLM on N/S | NLM on E/W	Positive	.2 dB
Ithaca	7/27/2012	9:43:30	NLM on N/S | NLM on E/W	Positive	.4 dB
Ithaca	7/27/2012	9:50:30	NLM on N/S | NLM on E/W	Positive	.1 dB
Ithaca	7/28/2012	3:01	NAU on N/S	Negative	.2 dB
Ithaca	7/28/2012	3:39	NAU on N/S	Negative	.4 dB
Ithaca	7/28/2012	3:57	NAU on N/S	Positive	.5 dB
Ithaca	7/28/2012	3:59	NAU on N/S	Positive	.5 dB
Ithaca	7/28/2012	4:19	NAU on N/S	Positive	.3 dB
Ithaca	7/28/2012	4:28	NAU on N/S	Negative	.2 dB

Ithaca	7/28/2012	6:37	NPM on E/W	Positive	.1 dB
Ithaca	7/28/2012	6:41	NPM on E/W	Positive	.5 dB
Ithaca	7/28/2012	6:54	NPM on E/W	Positive	.5 dB
Ithaca	7/28/2012	6:33	NAU on N/S	Negative	.3 dB
Ithaca	7/28/2012	6:45	NAU on N/S	Negative	.4 dB
Ithaca	7/28/2012	6:46	NAU on N/S	Negative	.3 dB
Ithaca	7/28/2012	6:47	NAU on N/S	Negative	.3 dB
Ithaca	7/28/2012	6:34:50	NLM on E/W	Positive	.5 dB
Ithaca	7/28/2012	7:04:30	NPM on E/W	Positive	.2 dB
Ithaca	7/28/2012	7:22	NPM on E/W	Positive	.2 dB
Ithaca	7/28/2012	7:04	NAU on N/S | NAU on E/W	Negative	.5 dB
Ithaca	7/28/2012	7:18	NAU on N/S | NAU on E/W	Negative	3 dB
Ithaca	7/28/2012	7:19	NAU on N/S | NAU on E/W	Negative	2.5 dB
Ithaca	7/28/2012	7:21	NAU on N/S | NAU on E/W	Negative	.8 dB
Ithaca	7/28/2012	7:39	NAU on N/S | NAU on E/W	Negative	.5 dB
Ithaca	7/28/2012	7:41	NAU on N/S | NAU on E/W	Negative	.8 dB
Ithaca	7/28/2012	7:43	NAU on N/S | NAU on E/W	Negative	.8 dB
Ithaca	7/28/2012	8:26	NAU on N/S	Negative	.5 dB
Ithaca	7/28/2012	8:27	NAU on N/S	Negative	.7 dB
Ithaca	7/29/2012	7:09	NAU on N/S	Positive	.3 dB
Ithaca	7/29/2012	7:18	NAU on N/S	Positive	.5 dB
Ithaca	7/30/2012	1:36	NAU on N/S	Positive	.7 dB
Ithaca	7/31/2012	5:53	NAU on N/S	Positive	.5 dB

Ithaca	8/1/2012	3:07	NAU on N/S | NAU on E/W	Negative	.8 dB
Ithaca	8/1/2012	3:50	NAU on N/S	Positive	.5 dB
Ithaca	8/1/2012	3:56	NAU on N/S	Positive	.3 dB
Ithaca	8/1/2012	4:05	NAU on N/S	Positive	.2 dB
Ithaca	8/1/2012	4:20	NAU on N/S	Positive	.2 dB
Ithaca	8/1/2012	5:12	NAU on N/S | NAU on E/W	Positive	.5 dB
Ithaca	8/1/2012	5:25	NAU on N/S | NAU on E/W	Positive	.8 dB
Ithaca	8/1/2012	5:27	NAU on N/S | NAU on E/W	Positive	.8 dB
Ithaca	8/1/2012	5:28	NAU on N/S | NAU on E/W	Positive	.8 dB
Ithaca	8/2/2012	1:22	NAU on N/S	Positive	1 dB
Ithaca	8/2/2012	5:37	NAU on N/S	Positive	1 dB
Ithaca	8/2/2012	7:05	NAU on N/S	Positive	2 dB
Ithaca	8/2/2012	7:14	NAU on N/S	Positive	2 dB
Ithaca	8/2/2012	7:18	NAU on N/S	Positive	3 dB
Ithaca	8/3/2012	6:36	NAU on N/S | NAU on E/W	Negative	1 dB
Ithaca	8/4/2012	3:36	NLM on N/S | NLM on E/W	Positive	3 dB
Ithaca	8/4/2012	3:53	NLM on N/S | NLM on E/W	Positive	2 dB
Ithaca	8/4/2012	4:33	NLM on N/S | NLM on E/W	Positive	2 dB
Ithaca	8/4/2012	4:44	NLM on N/S | NLM on E/W	Positive	2 dB
Ithaca	8/4/2012	5:41	NLM on N/S |	Negative	5 dB

			NLM on E/W		
Ithaca	8/4/2012	7:16	NAU on N/S	Negative	.3 dB
Ithaca	8/4/2012	10:02	NLM on N/S | NLM on E/W	Negative	.3 dB
Ithaca	8/4/2012	10:09	NLM on N/S | NLM on E/W	Positive	.5 dB
Ithaca	8/6/2012	1:38	NAA on N/S | NAA on E/W	Positive	1 dB
Ithaca	8/6/2012	1:39	NAA on N/S | NAA on E/W	Positive	.2 dB
Ithaca	8/6/2012	1:41	NAA on N/S | NAA on E/W	Positive	.3 dB
Ithaca	8/6/2012	6:10	NAU on N/S | NAU on E/W	Negative	1 dB
Ithaca	8/6/2012	6:18	NAU on N/S | NAU on E/W	Negative	1.2 dB
Ithaca	8/7/2012	8:07	NAU on N/S | NAU on E/W	Positive	.5 dB
Ithaca	8/7/2012	8:12	NAU on N/S	Negative	.3 dB
Ithaca	8/7/2012	8:44	NAU on N/S	Positive	.2 dB
Ithaca	8/7/2012	8:47	NAU on N/S | NAU on E/W	Positive	.2 dB
Ithaca	10-Aug	5:53	NAA on E/W	Positive	.5 dB
Ithaca	8/12/2012	1:22	NAA on E/W	Positive	.2 dB
Ithaca	8/12/2012	1:26	NAA on E/W	Positive	.1 dB
Ithaca	8/13/2012	4:28	NAA on N/S | NAA on E/W	Negative	.2 dB
Ithaca	8/14/2012	7:59	NAU on N/S	Negative	.3 dB
Ithaca	8/14/2012	8:01	NAU on N/S	Negative	.3 dB
Ithaca	8/14/2012	8:02	NAU on N/S	Negative	.2 dB

Ithaca	8/15/2012	2:53	NAA on E/W	Negative	1 dB
Ithaca	8/16/2012	2:11	NAU on N/S | NAU on E/W	Positive	1.5 dB
Ithaca	8/16/2012	3:39	NAU on N/S	Positive	.5 dB
Ithaca	8/16/2012	3:47	NAU on N/S	Positive	.4 dB
Ithaca	8/16/2012	3:21	NAA on E/W	Positive	.3 dB
Ithaca	8/16/2012	3:48	NAA on E/W	Positive	.2 dB
Ithaca	8/16/2012	4:05	NAU on N/S	Positive	.7 dB
Ithaca	8/16/2012	4:17	NAU on N/S	Positive	.5 dB
Ithaca	8/16/2012	4:19	NAU on N/S	Positive	.5 dB
Ithaca	8/16/2012	4:21	NAU on N/S	Positive	.4 dB
Ithaca	8/16/2012	6:44:45	NAA on N/S	Positive	.5 dB
Ithaca	8/16/2012	6:45:45	NAA on N/S	Positive	.5 dB
Ithaca	8/16/2012	6:47:15	NAA on N/S	Positive	.7 dB
Ithaca	8/16/2012	6:49:15	NAA on N/S	Positive	.4 dB
Ithaca	8/16/2012	7:36	NAU on N/S | NAU on E/W	Positive	.8 dB
Ithaca	8/16/2012	7:54	NAU on E/W	Positive	1 dB
Ithaca	8/16/2012	7:57	NAU on N/S | NAU on E/W	Positive	1 dB
Ithaca	8/16/2012	8:38	NLM on N/S | NLM on E/W	Positive	1 dB
Ithaca	8/16/2012	8:18	NAA on E/W	Positive	.2 dB
Ithaca	8/16/2012	8:19	NAA on E/W	Positive	.2 dB
Ithaca	8/16/2012	8:24	NAA on E/W	Positive	.2 dB
Ithaca	8/17/2012	2:27	NAU on N/S	Positive	.4 dB
Ithaca	8/17/2012	2:12	NLM on E/W	Negative	.3 dB
Ithaca	8/17/2012	2:13	NLM on E/W	Negative	.3 dB
Ithaca	8/17/2012	5:32	NAU on N/S	Negative	.3 dB
Ithaca	8/17/2012	5:49	NAU on N/S	Negative	.5 dB

Ithaca	8/17/2012	5:57	NAU on N/S	Negative	.3 dB
Ithaca	8/17/2012	8:21	NPM on E/W	Negative	4 dB
Ithaca	8/18/2012	5:04	NAU on N/S | NAU on E/W	Positive	.5 dB
Ithaca	8/18/2012	5:50	NAU on N/S	Positive	.8 dB
Ithaca	8/18/2012	5:56	NAU on N/S	Positive	.7 dB
Ithaca	8/18/2012	6:03	NAU on N/S	Positive	.5 dB
Ithaca	8/19/2012	5:45	NAU on N/S	Positive	.8 dB
Ithaca	8/19/2012	5:47	NAU on N/S | NAU on E/W	Negative	.7 dB
Ithaca	8/19/2012	6:04	NAU on N/S	Negative	.3 dB
Ithaca	8/19/2012	6:22	NAU on N/S	Positive	.1 dB
Ithaca	8/19/2012	7:44	NAU on N/S	Positive	.5 dB
Ithaca	8/19/2012	7:58	NAU on N/S	Positive	.8 dB
Ithaca	8/19/2012	8:02	NAU on N/S	Negative	.3 dB
Ithaca	8/19/2012	8:06	NLM on N/S	Positive	.5 dB
Ithaca	8/19/2012	8:09	NLM on N/S	Positive	.2 dB
Ithaca	8/19/2012	8:17	NLM on N/S	Positive	.5 dB
Ithaca	8/19/2012	8:29	NLM on N/S	Positive	.5 dB
Ithaca	8/20/2012	3:29	NAU on N/S	Negative	.5 dB
Ithaca	8/20/2012	5:19	NAU on N/S	Negative	.5 dB
Ithaca	8/20/2012	5:56	NAU on N/S	Negative	.5 dB
Ithaca	8/20/2012	6:18	NAU on N/S	Negative	1 dB
Ithaca	8/20/2012	7:24	NAU on N/S	Negative	.3 dB
Ithaca	8/20/2012	9:29	NPM on E/W	Negative	.5 dB
Ithaca	8/20/2012	9:47	NPM on E/W	Negative	1.5 dB
Ithaca	8/20/2012	13:03:30	NLM on N/S | NLM on E/W	Positive	.5 dB
Ithaca	8/21/2012	8:37:50	NAU on N/S | NAU on E/W	Negative	1 dB

Ithaca	8/21/2012	8:38:30	NAU on N/S | NAU on E/W	Negative	1.5 dB
Ithaca	8/22/2012	15:28	NAA on N/S | NAA on E/W	Negative	.3 dB
Ithaca	8/23/2012	5:52	NAU on N/S	Positive	.3 dB
Ithaca	8/23/2012	9:07	NLM on N/S | NLM on E/W	Positive	2 dB
Ithaca	8/24/2012	9:33	NLK on N/S | NLK on E/W	Positive	.7 dB
Ithaca	8/24/2012	9:37	NLK on N/S | NLK on E/W	Positive	.5 dB
Ithaca	8/24/2012	9:49	NLK on N/S | NLK on E/W	Positive	.5 dB
Ithaca	8/25/2012	5:18	NLM on N/S | NLM on E/W	Negative	.2 dB
Ithaca	8/25/2012	5:27	NLM on N/S	Positive	.3 dB
Ithaca	8/25/2012	5:32	NLM on N/S	Positive	.1 dB
Ithaca	8/25/2012	5:32	NLK on N/S | NLK on E/W	Positive	.2 dB
Ithaca	8/25/2012	9:17	NAU on N/S | NAU on E/W	Negative	2 dB
Ithaca	8/26/2012	3:05	NAU on N/S	Negative	1.5 dB
Ithaca	8/26/2012	3:09	NAU on N/S	Positive	.2 dB
Ithaca	8/26/2012	3:36	NAU on N/S	Positive	.5 dB
Ithaca	8/26/2012	4:03	NAU on N/S	Positive	.3 dB
Ithaca	8/26/2012	4:18	NAU on N/S	Positive	.2 dB
Ithaca	8/26/2012	4:39	NAU on N/S | NAU on E/W	Negative	.5 dB
Ithaca	8/26/2012	6:12	NAU on N/S | NAU on E/W	Positive	.5 dB

Ithaca	8/26/2012	6:18	NAU on N/S | NAU on E/W	Positive	.7 dB
Ithaca	8/26/2012	6:19	NAU on N/S | NAU on E/W	Positive	.3 dB
Ithaca	8/26/2012	6:22	NAU on N/S	Positive	.7 dB
Ithaca	8/26/2012	6:44	NAU on N/S | NAU on E/W	Negative	1 dB
Ithaca	8/26/2012	6:48	NAU on N/S | NAU on E/W	Negative	1 dB
Ithaca	8/26/2012	7:03	NAU on N/S | NAU on E/W	Negative	2 dB
Ithaca	8/26/2012	7:10	NAU on N/S | NAU on E/W	Negative	1.5 dB
Ithaca	8/26/2012	7:51	NAU on N/S	Positive	.4 dB
Ithaca	8/27/2012	8:32	NAU on N/S | NAU on E/W	Positive	.8 dB
Ithaca	8/27/2012	8:37	NAU on N/S | NAU on E/W	Positive	.5 dB
Ithaca	8/27/2012	8:56	NAU on N/S | NAU on E/W	Positive	.5 dB
Ithaca	8/27/2012	8:23	NAU on N/S | NAU on E/W	Negative	1 dB
Ithaca	8/27/2012	15:11	NAU on N/S | NAU on E/W	Negative	.2 dB
Ithaca	8/27/2012	15:32	NAU on N/S | NAU on E/W	Negative	.2 dB
Ithaca	8/27/2012	16:08:30	NAU on N/S | NAU on E/W	Positive	.1 dB
Ithaca	8/27/2012	16:08:45	NAU on N/S | NAU on E/W	Positive	.1 dB

Ithaca	8/27/2012	16:13:50	NAU on N/S | NAU on E/W	Positive	.1 dB
Ithaca	8/27/2012	20:15	NAU on N/S | NAU on E/W	Positive	.5 dB
Ithaca	4/4/2012	2:43	NLM on N/S | NLM on E/W	Positive	1.2 dB
Warsaw	4/6/2012	3:01	NAU on N/S | NAU on E/W	Positive	.5 dB
Warsaw	4/6/2012	3:35	NAU on N/S | NAU on E/W	Negative	1 dB
Warsaw	4/6/2012	5:07	NAU on N/S | NAU on E/W	Positive	.2 dB
Warsaw	4/6/2012	5:17	NAU on N/S | NAU on E/W	Positive	.8 dB
Warsaw	4/6/2012	5:28	NAU on N/S | NAU on E/W	Negative	1 dB
Warsaw	4/6/2012	8:39	NAU on E/W	Positive	.5 dB
Warsaw	4/6/2012	8:48	NAU on E/W	Negative	1 dB
Warsaw	4/6/2012	9:03	NAU on E/W	Positive	.2 dB
Warsaw	4/6/2012	9:09	NAU on E/W	Negative	.5 dB
Warsaw	4/6/2012	9:49	NAU on E/W	Positive	.4 dB
Warsaw	4/7/2012	4:34	NAU on E/W	Negative	.6 dB
Warsaw	4/7/2012	6:04	NAU on N/S | NAU on E/W	Positive	.4 dB
Warsaw	4/7/2012	6:09	NAU on N/S | NAU on E/W	Positive	.3 dB
Warsaw	4/7/2012	6:27	NAU on N/S | NAU on E/W	Positive	.3 dB
Warsaw	4/7/2012	6:34	NAU on N/S | NAU on E/W	Positive	.3 dB

Warsaw	4/7/2012	6:43	NAU on N/S | NAU on E/W	Positive	.7 dB
Warsaw	4/7/2012	6:47	NAU on N/S | NAU on E/W	Positive	.5 dB
Warsaw	4/7/2012	7:27	NAU on E/W	Positive	.5 dB
Warsaw	4/7/2012	7:28	NAU on E/W	Positive	.4 dB
Warsaw	4/7/2012	7:37	NAU on E/W	Positive	.4 dB
Warsaw	4/10/2012	2:29	NLM on N/S | NLM on E/W	Positive	.8 dB
Warsaw	4/10/2012	2:44	NLM on N/S | NLM on E/W	Positive	.6 dB
Warsaw	4/10/2012	2:39	NLM on N/S | NLM on E/W	Positive	.2 dB
Warsaw	4/11/2012	2:20	NLM on N/S | NLM on E/W	Positive	1 dB
Warsaw	4/11/2012	3:13	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	4/12/2012	7:07	NLM on E/W	Positive	.2 dB
Warsaw	4/12/2012	7:15	NLM on E/W	Negative	.2 dB
Warsaw	4/12/2012	7:41	NLM on E/W	Negative	.2 dB
Warsaw	4/12/2012	8:11	NAU on E/W	Positive	.2 dB
Warsaw	4/12/2012	8:39	NAU on E/W	Positive	.3 dB
Warsaw	4/12/2012	8:41	NAU on E/W	Negative	.1 dB
Warsaw	4/14/2012	10:18:50	NAU on N/S | NAU on E/W	Negative	10 dB
Warsaw	4/15/2012	3:44	NLM on N/S | NLM on E/W	Negative	5 dB
Warsaw	4/15/2012	4:28	NLM on N/S | NLM on E/W	Positive	1 dB
Warsaw	4/15/2012	4:41	NLM on N/S |	Positive	.5 dB

			NLM on E/W		
Warsaw	4/15/2012	6:26	NLK on N/S | NLK on E/W	Positive	1 dB
Warsaw	4/15/2012	6:09	NLK on N/S | NLK on E/W	Positive	1 dB
Warsaw	4/15/2012	6:19	NLM on N/S | NLM on E/W	Negative	.7 dB
Warsaw	4/15/2012	6:28	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	4/15/2012	9:55	NLM on N/S | NLM on E/W	Positive	.5 dB
Warsaw	4/18/2012	7:28	NLK on N/S | NLK on E/W	Negative	1 dB
Warsaw	4/18/2012	8:22	NLK on N/S | NLK on E/W	Negative	.5 dB
Warsaw	4/18/2012	8:28	NLK on N/S | NLK on E/W	Negative	.4 dB
Warsaw	4/22/2012	6:43	NAU on N/S | NAU on E/W	Negative	.5 dB
Warsaw	4/26/2012	8:45	NLK on N/S	Negative	5 dB
Warsaw	4/26/2012	8:45	NLM on N/S	Negative	1 dB
Warsaw	4/26/2012	9:16	NPM on N/S	Positive	3 dB
Warsaw	4/27/2012	2:42	NAA on N/S	Positive	.2 dB
Warsaw	4/27/2012	2:43	NAA on N/S | NAA on E/W	Negative	.6 dB
Warsaw	4/27/2012	3:01	NAA on N/S	Positive	.3 dB
Warsaw	4/27/2012	3:07	NAA on N/S	Positive	.2 dB
Warsaw	4/27/2012	3:24	NAA on N/S	Negative	.1 dB
Warsaw	4/27/2012	3:37	NAA on N/S	Negative	.2 dB
Warsaw	4/27/2012	4:36	NAA on N/S	Positive	.1 dB

Warsaw	4/27/2012	4:39	NAA on N/S	Negative	.1 dB
Warsaw	4/27/2012	4:47	NAA on N/S	Negative	.1 dB
Warsaw	4/27/2012	7:02	NAU on E/W	Negative	.1 dB
Warsaw	4/27/2012	7:03	NAU on E/W	Negative	.1 dB
Warsaw	4/27/2012	7:06	NAU on E/W	Negative	.2 dB
Warsaw	4/29/2012	3:27	NAA on N/S | NAA on E/W	Negative	.3 dB
Warsaw	4/29/2012	3:27	NLM on N/S | NLM on E/W	Negative	.1 dB
Warsaw	4/29/2012	3:39	NLM on N/S | NLM on E/W	Negative	.4 dB
Warsaw	4/29/2012	3:58	NLM on N/S | NLM on E/W	Negative	.7 dB
Warsaw	4/29/2012	5:45	NLM on N/S | NLM on E/W	Negative	.4 dB
Warsaw	4/29/2012	6:33	NLM on N/S | NLM on E/W	Negative	1 dB
Warsaw	4/29/2012	7:36	NLK on N/S | NLK on E/W	Positive	2 dB
Warsaw	4/29/2012	7:38	NLK on N/S | NLK on E/W	Positive	1.5 dB
Warsaw	4/29/2012	7:36	NLM on N/S | NLM on E/W	Positive	1 dB
Warsaw	4/29/2012	7:38	NLM on N/S | NLM on E/W	Positive	1 dB
Warsaw	4/29/2012	7:38	NAA on N/S | NAA on E/W	Negative	.2 dB
Warsaw	5/1/2012	6:17	NLM on N/S | NLM on E/W	Negative	1 dB
Warsaw	5/1/2012	6:25	NLM on N/S |	Negative	1 dB

			NLM on E/W		
Warsaw	5/1/2012	9:30	NPM on N/S	Negative	3 dB
Warsaw	5/2/2012	3:51	NLM on N/S	Positive	1 dB
Warsaw	5/2/2012	3:53	NLM on N/S	Negative	1 dB
Warsaw	5/2/2012	4:09	NLM on N/S | NLM on E/W	Negative	4 dB
Warsaw	5/2/2012	4:19	NLM on N/S | NLM on E/W	Negative	2 dB
Warsaw	5/2/2012	4:26	NLM on N/S | NLM on E/W	Negative	1 dB
Warsaw	5/2/2012	4:28	NLM on N/S | NLM on E/W	Negative	2 dB
Warsaw	5/2/2012	8:53	NAA on N/S | NAA on E/W	Negative	.5 dB
Warsaw	5/2/2012	8:08	NLM on N/S | NLM on E/W	Positive	.7 dB
Warsaw	5/2/2012	8:28	NLM on N/S | NLM on E/W	Positive	.6 dB
Warsaw	5/3/2012	6:52	NAA on N/S | NAA on E/W	Positive	.2 dB
Warsaw	5/3/2012	7:16	NAA on N/S | NAA on E/W	Positive	.3 dB
Warsaw	5/5/2012	1:54:50	NAA on E/W	Positive	.2 dB
Warsaw	5/5/2012	5:14	NAU on N/S | NAU on E/W	Negative	.5 dB
Warsaw	5/5/2012	5:16	NAU on N/S | NAU on E/W	Negative	1 dB
Warsaw	5/6/2012	1:14	NAA on E/W	Positive	.5 dB
Warsaw	5/6/2012	7:37	NAU on N/S | NAU on E/W	Positive	.7 dB

Warsaw	5/6/2012	7:08	NAU on N/S | NAU on E/W	Positive	1 dB
Warsaw	5/10/2012	6:17	NAU on E/W	Positive	.5 dB
Warsaw	5/10/2012	6:46	NAU on E/W	Positive	.8 dB
Warsaw	5/10/2012	7:06	NAU on N/S | NAU on E/W	Positive	.7 dB
Warsaw	5/10/2012	7:09	NAU on N/S | NAU on E/W	Positive	.5 dB
Warsaw	5/10/2012	7:31	NAU on N/S | NAU on E/W	Positive	.5 dB
Warsaw	5/10/2012	7:34	NAU on N/S | NAU on E/W	Positive	.8 dB
Warsaw	5/10/2012	8:31	NAU on N/S | NAU on E/W	Positive	.8 dB
Warsaw	5/10/2012	8:38	NAU on N/S | NAU on E/W	Positive	1 dB
Warsaw	5/13/2012	5:36	NAU on E/W	Negative	.3 dB
Warsaw	5/13/2012	5:38	NAU on E/W	Negative	.7 dB
Warsaw	5/13/2012	5:53	NAU on E/W	Negative	.4 dB
Warsaw	5/13/2012	6:08	NAU on E/W	Negative	.5 dB
Warsaw	5/13/2012	6:14	NAU on E/W	Negative	.4 dB
Warsaw	5/13/2012	6:29	NAU on E/W	Negative	.5 dB
Warsaw	5/13/2012	7:06	NAU on N/S | NAU on E/W	Negative	1 dB
Warsaw	5/13/2012	8:21	NAA on N/S | NAA on E/W	Negative	.4 dB
Warsaw	5/13/2012	8:44	NAU on N/S | NAU on E/W	Negative	.4 dB
Warsaw	5/13/2012	8:46	NAU on N/S | NAU on E/W	Negative	.5 dB

Warsaw	5/14/2012	3:14	NAU on N/S | NAU on E/W	Negative	.2 dB
Warsaw	5/15/2012	7:04	NAU on N/S | NAU on E/W	Negative	.4 dB
Warsaw	5/15/2012	7:38	NAU on N/S | NAU on E/W	Positive	.7 dB
Warsaw	5/17/2012	4:05	NAA on N/S | NAA on E/W	Negative	.5 dB
Warsaw	5/17/2012	4:18	NAA on N/S	Positive	.5 dB
Warsaw	5/17/2012	7:57	NAU on N/S | NAU on E/W	Negative	.7 dB
Warsaw	5/19/2012	3:04	NLM on N/S | NLM on E/W	Positive	.5 dB
Warsaw	5/19/2012	3:37	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	5/19/2012	4:33	NLM on N/S | NLM on E/W	Positive	.5 dB
Warsaw	5/20/2012	6:32	NLM on N/S | NLM on E/W	Positive	1 dB
Warsaw	5/20/2012	6:43	NLM on N/S | NLM on E/W	Positive	1.5 dB
Warsaw	5/21/2012	2:57	NAU on N/S | NAU on E/W	Positive	.2 dB
Warsaw	5/21/2012	3:04	NAU on E/W	Positive	.2 dB
Warsaw	5/21/2012	3:27	NLM on N/S	Negative	.4 dB
Warsaw	5/21/2012	4:07	NAU on N/S | NAU on E/W	Positive	.3 dB
Warsaw	5/21/2012	4:27	NAU on E/W	Positive	.2 dB
Warsaw	5/21/2012	4:38	NAU on N/S | NAU on E/W	Negative	.5 dB

Warsaw	5/21/2012	5:42	NLM on N/S | NLM on E/W	Positive	.5 dB
Warsaw	5/21/2012	5:56	NLM on N/S | NLM on E/W	Positive	1.5 dB
Warsaw	5/21/2012	7:26	NAA on N/S | NAA on E/W	Positive	.2 dB
Warsaw	5/22/2012	6:07	NAU on N/S | NAU on E/W	Positive	.5 dB
Warsaw	5/22/2012	6:13	NAU on N/S | NAU on E/W	Positive	.2 dB
Warsaw	5/22/2012	6:16	NAU on E/W	Positive	.4 dB
Warsaw	5/22/2012	6:08	NAU on N/S | NAU on E/W	Negative	.3 dB
Warsaw	5/22/2012	6:27	NAU on N/S | NAU on E/W	Negative	2 dB
Warsaw	5/24/2012	3:42	NLM on N/S | NLM on E/W	Negative	.5 dB
Warsaw	5/24/2012	5:08	NLM on N/S | NLM on E/W	Negative	2 dB
Warsaw	5/25/2012	1:32	NAU on N/S | NAU on E/W	Negative	.4 dB
Warsaw	5/26/2012	5:28:10	NAA on N/S | NAA on E/W	Negative	.4 dB
Warsaw	5/27/2012	1:48	NAU on N/S | NAU on E/W	Negative	.5 dB
Warsaw	5/27/2012	4:11	NLM on N/S | NLM on E/W	Positive	.2 dB
Warsaw	5/27/2012	4:23	NLM on N/S | NLM on E/W	Positive	.1 dB
Warsaw	5/27/2012	4:31	NLM on N/S |	Negative	.2 dB

			NLM on E/W		
Warsaw	5/27/2012	17:12	NAU on N/S | NAU on E/W	Negative	.3 dB